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APPLIED MECHANICS REVIEWS

VOL. 8, NO. 3 MARTIN GOLAND *Editor* MARCH 1955

ANALYSIS OF FRAMED STRUCTURES

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FRAMED structures are systems of bars with rigid joints. The rigidity of joints causes the bending of bars with equal rotation of all bars connected in a joint. Trussed girders, with (actual or supposed) hinged connections at the joints are determinate or overdeterminate in form, whereas framed structures (without diagonals) having hinged joints are geometrically indeterminate. With rigid joints, the bars in *plane systems* are acted on by axial forces, bending moments, and shearing forces. This greatly increases the number of unknowns, framed structures being many times statically indeterminate. Exact solution with usual methods is complicated and laborious. The greatest possible simplification of analysis for practical purposes is the aim of all new publications.

As in the case of all hyperstatic systems, framed structures can be analyzed by Castigliano's *method of least work* (1).[1] The statically indeterminate quantities are the components of reactions or internal forces (axial and shearing forces, bending moments) in chosen sections. Expressing by these unknowns the components of internal forces in all sections of the bars, we derive by the theorem of least work as many equations as there are unknowns. We then have a great number of linear equations. This method of analysis is simple if each equation contains only a small number of unknowns. For this purpose, it is possible to choose the sections containing hyperstatic components and their directions so that each hyperstatic quantity produces deformation in the least number of directions, least affects the other unknowns (2, 3). For a closed or fixed-end simple frame, each elastic equation can contain only one unknown if the components of internal forces in a section or of reactions are transferred to the elastic center of the frame.

The analysis of continuous beams with unyielding supports successfully uses *fixed points*, introduced by C. Culmann (4). This method of analysis can be applied also to framed structures (5). If only one member in the system is loaded, the bending moments in each unloaded member are given by a straight line which meets the axis of the member in a fixed point. Calculating in advance the fixed points in all members, we can determine the bending moments in all members for only one member loaded; from bending moments, we compute simply the shearing and axial forces. This method is advantageous for a frame whose joints are immovable, as is the case for a symmetrical and symmetrically loaded frame or for a frame whose supports prevent displacement of joints for every loading. If the joints move, equilibrium cannot be calculated as in the case of immovable joints. It is then necessary to put the system in equilibrium by suppressing the forces obtained in some joints as the resultants of internal forces; a new calculation must be made.

Instead of stress or reaction components, the analysis of frames can use as unknowns components of deformation; e. g., joint and bar rotations. The number of these unknowns is generally much smaller as compared to the number of statically indeterminate components of internal or external forces; this substantially facilitates the calculations. The origin of this slope-deflection method can be traced to J. Cl. Maxwell (6). For the solution of secondary stresses in trusses, this method was applied by H. Manderla (7), E. Winkler (8), and O. Mohr (9). For frames, this method was systematically elaborated by A. Ostenfeld (10). Slope-deflection method can be applied for simultaneous loading of many or all members.

Shortly after receiving the manuscript for Professor Bažant's article, we were saddened to learn of his death in September of last year. It is fitting that this magazine should pay tribute to the passing of an eminent scientist by publishing one of his last works, an appraisal of a broad and important branch of engineering science. The Editor

The basic equations for calculation by the slope-deflection method are joint equations (following from equilibrium of bending moments in joints) and bent equations (expressing the equilibrium of horizontal components of external and internal forces for a section through one story). With respect to unknown angles, all these equations are linear equations with a large number of unknowns. Precise solution is possible by successive substitution, or by Gauss' method of elimination, for a determinant symmetrical to the diagonal by shortened elimination (11). A great number of equations can be solved by successive approximation or iteration. For frames with many stories and bays, we can choose a simpler system as a part of the given structure and calculate from it the original system.

The laborious solution of the slope-deflection equations can be avoided by the *method of moment distribution*, which calculates

[1] Numbers in parentheses indicate References at end of paper.

successively, and very simply, the end moments in members. The method is due to H. Cross (12, 13). Similar to the method of fixed points, this method calculates directly the distribution of resultant (unbalanced) moments at the joints in the members meeting at a joint, as well as their carry-over to the other end of each member. After determining the distribution and carry-over factors, end moments in members can be calculated directly by successive approximation, which allows an exactness to any desired degree. The method has the advantage that errors of calculation can be improved by further distribution without correcting the previous solution. This method is very simple in principle. It solves no equations, and all computations consist of the simplest arithmetic. Especially simple is the analysis of frames whose joints do not move. But also for moving joints, this method is advantageous if moment distribution is combined with the distribution of forces acting in horizontal sections through stories (14). Another advantage is that bending moments necessary for proportioning of sections can be derived directly.

Another method of frame analysis uses deformation of the system, determined by joint rotations, as hyperstatic quantities. This method first calculates primary joint rotations, caused by the loading of members connected at the joint, and distributes them to next joints as secondary rotations which add to the primary. Repeating this solution, any desired accuracy can be achieved. This method, called *distribution of deformation*, was first applied by G. A. Maney and W. M. Wilson (15) and was improved in later publications (e. g., 16). The late C. Klouček occupied himself in detail with this method (17, 18). In many cases the method gives precise results at once, without repeated calculations.

Derived originally for the calculation of hyperstatic pin-jointed trusses, the *relaxation method* was also used by its author, R. V. Southwell (19), for analysis of continuous beams and frames; for continuous beams, the method is identical with the older moment distribution method. The relaxation method can be applied analogically to other physical problems (electrical networks, vibrations, elastic stability, stiffened suspension bridges, etc.).

The foregoing methods are good for any frame system. There are also methods for special cases. One of them is the *method of four moment equations* (20), using bending moments as hyperstatic quantities. This method solves simpler systems: continuous frames of one story and one-bay multistory frames.

Successive approximation methods also include the *panel method*, starting from a quadrilateral panel as an element of the structure (21). It has been applied to one-bay frames with several stories, having vertical or inclined columns; also for the Vierendeel girder (22) and for the complicated case of a hingeless spandrel-braced arch (23).

In simple cases (continuous beams and frames, closed frames) a quick calculation is given by the *method of relative flexure factors* (24, 25). This method determines very simply the tangents to the elastic line in joints of the system loaded in any member with bending moment at the joint. Thus is derived the elastic line of the system and the influence line of end-moment in a member.

All the foregoing methods concern plane frames. There is an abundant literature dealing with them in many languages (Czech, Italian, Polish, Russian, etc). Their theory is very advanced, as concerns the numerous methods and their practical applicability. The analysis of *space frames* is much more complicated. It is necessary to consider in every joint components of internal forces in three perpendicular directions, and also moments (bending or torsional) relative to all three axes. The number of components of deformation increases in the same proportion. The literature about space frames is comparatively rare. See, e. g., (26, 27).

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Books Received for Review

ADDISON, H., A treatise on applied hydraulics, 4th rev. and enlarged ed., New York, John Wiley & Sons, Inc., 1954, vii + 724 pp. $9.50.

BECKER, R. A., Introduction to theoretical mechanics (International Series in Pure and Applied Physics), New York, Toronto, London, McGraw-Hill Book Co., Inc., 1954, xiii + 420 pp.

GATLAND, K. W., Development of the guided missile, New York, Philosophical Library; London, Iliffe & Sons, Ltd., 1954, 292 pp. $4.75.

HANSEN, J. B., Earth pressure calculations, Copenhagen, Danish Technical Press (Teknisk Forlag), 1953, 271 pp.

HILBERT, H. L., Stanzereitechnik. Bd. 1. Schneidende Werkzeuge, 5th rev. ed., München, Carl Hanser Verlag, 1954, 349 pp., 350 figs., 33 tables. DM 19.80.

HOUGEN, O. A., WATSON, K. M., AND RAGATZ, R. A., Chemical process principles. Part I. Material and energy balances,

2nd ed., New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1954, xxxv + 504 pp. $8.50.

KRONENBERG, M., Grundzuge der Zerspanungslehre. Bd. I. Einschneidige Zerspanung, 2nd enlarged and rev. ed., Berlin, Springer-Verlag, xxvi + 430 pp., 293 figs.

LEINWEBER, P., edited by, Taschenbuch der Längenmesstechnik (in co-operation with Berndt, G., and Kienzle, O.), Berlin, Springer-Verlag, 1954, xxiii + 806 pp., 790 figs., 39 tables. DM 27.

MITTAG, C., Prüfverfahren zur Ermittlung von Höchstleistungsten in Kugel- und Rohrmühlen, Berlin, Springer-Verlag, 1954, v + 41 pp., 8 figs., 2 tables. DM 6.

MORGAN, P., edited by, Glass reinforced plastics, New York, Philosophical Library; London, Iliffe & Sons, Ltd., 1954, viii + 248 pp. $10.

PERRON, O., Die Lehre von den Kettenbrüchen. Bd. I. Elementare Kettenbrüche. 3rd ed., Stuttgart, B. G. Teubner Verlagsgesellschaft, 1954, vi + 194 pp.

PLANK, R., edited by, Handbuch der Kältetechnik. Bd. I. Entwicklung, wirtschaftliche Bedeutung, Werkstoffe, Berlin, Springer-Verlag, 1954, xviii + 567 pp., 322 figs. DM 84.

PRESS, H., Stauanlagen und Wasserkraftwerke. III. Wasserkraftwerke. Berlin, Wilhelm Ernst & Sohn, 1954, vii + 340 pp. DM 35.

REUTER, H., Methoden und Probleme der Wettervorhersage, Wien, Springer-Verlag, 1954, viii + 161 pp., 46 figs. $5.25.

SCHOUTEN, J. A., Ricci-Calculus, 2nd ed. (Grundlehren der mathematischen Wissenschaften, Bd. 10), Berlin, Springer-Verlag, 1954, xx + 516 pp., 16 figs. DM 55.

SZABÓ, I., Einfuhrung in die Technische Mechanik, Berlin, Springer-Verlag, 1954, xii + 383 pp., 484 figs. DM 19.50.

THOMAS, A. K., Die Tragfähigkeit der Zahnräder, 2nd ed., München, Carl Hanser Verlag, 1954, 182 pp., 88 figs., 35 tables. DM 14.80.

THOMAS, W., Reibscheiben-Regelgetriebe (edited by Niemann, G.) (Schriftenreihe Antriebstechnik, H. 4), Braunschweig, Friedr. Vieweg & Sohn, 1954, viii + 79 pp., 76 pp. of figs., tables. DM 19.80.

WILLIAMS, J. D., The compleat strategyst, New York, Toronto, London, McGraw-Hill Book Co., Inc., 1954, xiii + 234 pp. $4.75.

Letters to the Editor

541. Re AMR 7, Rev. 3233 (October 1954): J. P. Benthem and R. Kruithof, Investigation on the strength of 24S-T Alclad riveted and bolted lap joints at rapidly applied loads.

The first sentence of the second paragraph should read: "The load was applied to the specimens within a short time, which ranged from 0.01 sec up to 1.5 sec, while load-versus-time diagrams were recorded."

The editors regret this error.

542. Re AMR 7, Rev. 4011 (December 1954): L. Malmquist, A vapor-pressure equation for an extremely wide temperature range (in Swedish).

The editors regret the appearance of several errors in this review. The correct review is printed in full in this issue as Rev. 786.

Theoretical and Experimental Methods

(See also Revs. 560, 567, 570, 576, 577, 648, 694, 697, 717, 755, 776, 801, 802, 812)

543. Flügge, W., Four-place tables of transcendental functions, New York, McGraw-Hill Book Co., Inc.; London, Pergamon Press, Ltd., 1954, 136 pp. $5.

Publications on function tables belong to two categories: (1) elaborate new tables of unevaluated or inadequately tabulated functions; (2) abridged tabulation of a variety of functions for the sake of handier use. A good yardstick for the latter group is Jahnke-Emde, which started out at the turn of the century in category (1) but ended, because of the progress of the past two decades, as a respected member of category (2). Jahnke-Emde splits category (2) into the class of books which are less comprehensive but more handy (if they contain the information you are looking for), and books which are more comprehensive but less handy. In an alternate way of splitting, Jahnke-Emde divides category (2) (to this reviewer's mind) into the class of books whose notation is easier to follow, and the two sets of tables, Bierens de Haan and Campbell-Foster.

Flügge's book is a notable contribution to the first class of category (2) by both methods of subdivision. Although quite small, it packs a great amount of useful material into its pages and is by no means "included" in Jahnke-Emde. By carefully weighing the method of presentation, the choice of symbols, the order of listing the formulas, the juxtaposition of similar and contrasting features of related functions, Flügge has produced a collection of tables and formulas whose outstanding features are lucidity and the facility with which one can locate and remember the desired information. Tables to four significant figures are given for trigonometric, hyperbolic, logarithmic, and exponential functions, for the error function, for ordinary, modified, and Kelvin-type Bessel functions (of first and second kind and orders 0 and 1), as well as for elliptic integrals, Fresnel integrals, sine, cosine, and exponential integrals. Convergent and asymptotic formulas are provided for determination of function values outside the tabulated range. In a rapid perusal of the text the reviewer noticed only two places where more information seemed to be in order. On page 29 the integral of $dx/\ln x$ should show the limits 0 and x (so that the definition of $\overline{Ei}$ be consistent with page 115); correspondingly $\overline{Ei}\,x$ further up on the page must also be adjusted. The other thing that initially tripped the reviewer was the cryptic statement on p. 116: "Author's notation: $Ei(x)$ for $\overline{Ei}(x)$." (Such statements also occur elsewhere.) When expanded, this means: The master tables used in the preparation of the present book employ the notation $Ei(x)$ where we use the notation $\overline{Ei}(x)$.

Summing up, the book can be highly recommended to all present and future users of tables and formulas.

G. Horvay, USA

544. Table of sine and cosine integrals for arguments from 10 to 100 (reissue of Mathematical Tables 13), U. S. Dept. of Comm., Nat. Bur. Stands., Appl. Math. Ser. 32, 186 pp., 1954. $2.25.

In this reissue the bibliography has been brought up to date. A table to facilitate interpolation with second central differences has been added.

Y. L. Luke, USA

545. LaFara, R. L., A method for calculating inverse trigonometric functions, *Math. Tables Aids Comput.* **8,** 47, 132–139, July 1954.

Let $\sin y$ and $\cos y$ be known. Compute $\sin^{2n} y$, $n = 1,2,\ldots$ and note the sign. Each stage of process defines lower and

upper limits of y. Range decreases as n increases. Algorithm converges slowly, but, in view of recurrence relations, is suitable for use on automatic computing equipment possessing a limited amount of high-speed storage. Two general flow diagrams and steps for programming on IBM CPC are presented.

Y. L. Luke, USA

546. Churchill, R. V., The operational calculus of Legendre transforms, *J. Math. Phys.* **33, 2, 165–178, July 1954.**

Author considers the application of Legendre transforms to the problem of solving differential equations. The Legendre transform is given by $f(n) = {}_1\int^1 F(x)P_n(x)dx$, where $P_n(x)$ is the Legendre polynomial of degree n. An operational calculus is developed and a short table of transforms of particular functions is presented. Application is made to some classical problems in potential theory, such as the Dirichlet and Neumann problems for the sphere and to the third boundary-value problem for the potential inside a sphere. Solution to this last problem leads to a simple expression in terms of the solution of a corresponding Dirichlet problem which seems to be new.

A. Devinatz, USA

547. Levin, J. J., and Levinson, N., Singular perturbations of non-linear systems of differential equations and an associated boundary layer equation, *J. rational Mech. Anal.* **3, 2, 247–270, Mar. 1954.**

Relationship of solutions of differential system of boundary layer type [1] when $\epsilon \to 0+$, and its degenerate system [2]

$$\left.\begin{aligned} dx/dt &= f(x,y,t,\epsilon) \\ \epsilon^r(dy/dt) &= q(x,y,t,\epsilon) \end{aligned}\right\} \quad [1] \qquad \left.\begin{aligned} dx/dt &= f(x,y,t,0) \\ 0 &= g(x,y,t,0) \end{aligned}\right\} \quad [2]$$

was studied. x, f, y, g are real vectors of dimension $\geqslant 1$, and $r > 0$ is a fixed constant.

Authors were able to establish (Theorem I) the existence and uniqueness of solution $x(t,\epsilon)$, $y(t,\epsilon)$ of system [1] (satisfying the initial condition $x(a,\epsilon) = \Phi(a,\epsilon), y(a,\epsilon) = \Psi(a,\epsilon)$) in the neighborhood of solution $\phi(t)$, $\psi(t)$ of system [2], over a closed finite interval $a \leqslant t \leqslant b$; i.e.,

$$|x(t,\epsilon) - \phi(t)| + |y(t,\epsilon) - \Psi t)| \to 0$$

uniformly over the closed interval, as

$$\epsilon + |\Phi(a,\epsilon) - \phi(a)| + |\Psi(a,\epsilon) - \psi(a)| \to 0$$

under the following hypotheses:

(H_1): System (2) possesses a solution $x = \phi(t)$, $y = \psi(t)$, continuously differentiable on closed finite interval $a \leq t \leq b$.

(H_2): In the region R: $|x - \phi(t)| < \delta_0$, $|y - \psi(t)| < \delta_0$, $a \leq t \leq b$, $0 \leq \epsilon \leq \delta_0$, $f, g, f_x, g_x, f_y, g_y \in C$ with respect to (x,y,t,ϵ).

(H_3): Real parts of all the characteristic roots of square matrix $g_\psi(t) = [(\partial g_i/\partial y_j)\ (\phi(t), \psi(t), t, 0)]$, $i, j = 1,2,\ldots, n$, are $\leq -\mu < 0$ on $a \leq t \leq b$.

Improvements to the conclusions to cover more general bound of $|\Psi(a) - \psi(a)|$—so that the initial points do not approach—were offered by suitably modifying H_3 and resulted in (Theorem II) the existence and uniqueness of solution $x(t,\epsilon)$, $y(t,\epsilon)$ of system (1), (satisfying initial condition $x(a,\epsilon) = \phi(a)$, $y(a,\epsilon) = \Psi(a)$), for sufficiently small ϵ, over a closed finite interval $a \leq t \leq b$; and $|x(t,\epsilon) - \phi(t)| + |y(t,\epsilon) - \psi(t)| \to 0$ uniformly over $a < t \leq b$; as $\epsilon \to 0+$.

Generalization of the results to systems involving more dependent variables and higher powers of ϵ were also presented.

It was remarked that H_3 coincides with the hypothesis introduced by Friedrich and Wasow in dealing with the same problem but with y as vector of dimension one. The relative merits between H_3 and Tihonov's condition of negative definiteness of a certain quadratic form (corresponding to matrix g_ψ) plus higher-order terms in the neighborhood of the solution of degenerate system were also briefly discussed, and it was pointed out that the latter condition is more powerful only if the quadratic form identically vanishes; otherwise H_3 is more general.

H. S. Tan, USA

548. Heinhold, J., and Albrecht, R., On the practice of conformal mapping (in German), *R. C. Circ. Mat. Palermo* (II) III, I, 130–148, 1954.

An analytic function $w = f(z)$, mapping conformly a (simply connected) region B into the interior of a circle, can be determined exactly only in a few simple cases. Otherwise, the problem of determining the function $f(z)$ is solved approximately. For this purpose, some methods are worked out. For the most part, they converge sufficiently rapidly to the desired function $f(z)$, if the region is close to a circle (case I). If the region differs from the circle very much (case II), it seems to be convenient to begin with a transformation, mapping this region to a region B', close to a circle, and then to use one of the methods which rapidly converge to the function $f(z)$.

In the paper, one of the approximative methods for determining the function $f(z)$—the so-called "Schmiegungsmethod"—is described, effective in case II. The paper shows methods for determining the so-called "Schmiegungsfunctions" and gives a generalized method, in which all these methods are included.

The paper is exactly and clearly written.

K. Rektorys, Czechoslovakia

549. Crandall, S. H., Numerical treatment of a fourth order parabolic partial differential equation, *J. Assn. Comput. Mach.* **1, 3, 111–118, July 1954.**

Paper deals with finite difference approximations to the partial differential equation and boundary conditions which represent the problem of predicting the transient response of a uniform flexible beam clamped at both ends with initially known displacements and velocities. Author describes an implicit approximation formula which takes into account the parabolic nature of the continuous system. Theoretical and computational comparisons are made with a more straightforward explicit method. The results presented indicate the superiority of the implicit technique.

M. L. Stein, USA

550. Mises, R. v., Numerical computation of multidimensional integrals (in German), *ZAMM* **34, 6, 201–210, June 1954.**

In 1936, author gave a theory of numerical cubature [*Revue Mathématique de l'Union Interbalkanique* **6, 1, 1936,** fasc. 1] that has since then been treated differently in other papers [Mauro Picone, *Ann. Scu. norm. sup.* Pisa, (III) **V,** fasc. III-IV, 1951; Carlo Birindelli, *Compositio Matematica,* **10,** 117–167, 1952]. The theory is generalized to an arbitrary range of integration in the k-dimensional space and some examples are given.

From author's summary by C. B. Biezeno, Holland

551. Baldacci, R. F., On the solution of the equations for statically indeterminate elastic systems (in Italian), *Atti Inst. Sci. Costr. Univ. Pisa. Publ.* 30, 28 pp., 1953.

Classical numerical methods of solution of systems of linear algebraic equations are reviewed. Some examples of application of these methods to the solution of specific problems of statically undetermined elastic systems are illustrated.

E. Volterra, USA

552. **Mittman, M. J., Contribution to empirical functions** (in German), *ZAMM* **34,** 1/2, 37–43, Jan./Feb., 1954.

553. **Folse, J. A., Some applications of the theory of least squares to research and development of engineering equipment,** ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-11, 12 pp.

554. **Bergman, S., A method for solving boundary value problems of mathematical physics on punch card machines,** *J. Assn. Comput. Mach.* **1,** 3, 101–104, July 1954.

Paper applies previously developed methods of Bergman to obtain solutions of the differential equations

$$\tfrac{1}{4}\,\Delta\mu + au_x + bu_y + Fu = 0$$

where

$$\Delta\mu = (\partial^2 u/\partial x^2) + (\partial^2 u/\partial y^2);\ u_x = \partial u/\partial x$$

and a, b, F are entire functions of x and y. Computations occurring in the cases $a = b = F = 0$ and $a = b = 0$, F a polynomial, are described. Author shows that the evaluation of particular solutions can be accomplished without integrations, i.e., by use of the four elementary operations of arithmetic and hence conveniently by punch-card machines. M. L. Stein, USA

555. **Wasel, A. D., A method of determining plate bending by use of a punched-card machine,** *J. Assn. Comput. Mach.* **1,** 3, 105–110, July 1954.

Author applies techniques of Bergman (see preceding review) to the solution of boundary-value problems of the theory of plate deflection. Detailed descriptions are given of the operations necessary to carry out the computations on punched-card machines. M. L. Stein, USA

556. **Kiss, I., The theoretical basis of mechanical root extraction** (in German), *Acta Techn. Hung. Budapest* **8,** 3/4, 221–240, 1954.

Author reduces the problem of extracting roots to that of the solution of algebraic equations. By this means he has succeeded in the uniform deduction of the known approximate radical formulas (Heron, Lambert, Merrifield) and in completing them up to the fifth degree of approximation. By recurrence he presents a novel generalization of the Newton-Raphson procedure; the above formulas are simple applications of the latter. Gornstein's method leads to the same generalization in the case of the maximum precision attainable. The formula of radical approximation, supplied by the generalization of Newton's procedure suggested by Euler, is presented. An example illustrates the efficiency of the results obtained. From author's summary

557. Salmon, G., A treatise on conic sections. An account of some of the most important modern algebraic and geometric methods, New York, Chelsea Publishing Co., 1954, xv + 399 pp. $1.94.

558. Luckey, P., Nomography [Nomographie] (7th ed. revised by Treusch, W.), Stuttgart, B. G. Teubner, 1954, 124 pp., 65 figs. DM 5.60.

Book is intended primarily for those who seek a practical guide to the construction of graduations, diagrams, alignment charts, and of other similar kinds of graphical aids. In the new edition (6th ed. appeared in 1949), three chapters on some special slide rules, on practical steps during the construction of a nomogram, and on the precision of nomograms are added. Examples and 49 exercises, taken from all parts of engineering and many of them worked out in detail, are included. References on some special nomograms are given in the text and at the end of the book; a bibliography and a list of equations treated are added. Exposition is clear and only a limited knowledge of elementary mathematics is presupposed. Book can be also recommended as a first introduction to the field. A. Kuhelj, Yugoslavia

559. Meyer zur Capellen, W., Guide to nomography [Leitfaden der Nomographie], Berlin, Springer-Verlag, 1953, iv + 178 pp., 203 figs. DM 12.

Book covers whole field of nomography, here broadly defined as "graphical representation of relations between variables, in such form that the corresponding values may be conveniently read off." Starting with coordinate systems and scales of units, book treats function scales, various types of slide rules, families of curves, and the various transformations which are possible using function graph papers, and standard types of line nomograms. Relation between line nomograms and families of curves is discussed from standpoint of principle of duality in projective geometry. Errors introduced in reading nomograms are given careful treatment throughout. Book is about equally divided into *fundamentals,* deriving all basic mathematical relations in nomograms from first principles; and *examples and applications,* which are given in sufficient detail to enable reader to construct for himself any type of nomogram discussed.

Book is recommended as a text and a convenient reference for anyone seeking concise information in this field. Its value as a reference is enhanced by inclusion of an index of functional types treated as well as a subject index and an extensive list of references. T. P. Goodman, USA

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 594, 597, 865, 885, 887)

560. Pars, L. A., Introduction to dynamics, New York, Cambridge Univ. Press, 1953, xxii + 501 pp. $6.

This book is the outgrowth of lectures on elementary dynamics for first-year undergraduates by the author in Cambridge. The author presumes a knowledge of elementary statics and a working knowledge of the elements of the calculus. He defines the scope of his book as the study of motion in two dimensions without Lagrange's equations.

He artfully steers the course of the book between Scylla and Charybdis: the extremes of "let's teach them dynamics without calculus" on one hand, and "it is indeed unfortunate that our vector thought must be diluted by physical problems and the press for an answer" on the other. The author neither avoids calculus and vectors nor seeks to incur complication; rather he proceeds directly to the solution.

The book introduces scalar and vector quantities, vector algebra, and vector calculus prior to the consideration of the fundamental notions of Newtonian mechanics. The consideration of linear motion serves as an introduction to motion in a force held. The study of energy, impulse, collision, and variable mass precedes the study of constrained and free emotion in a conservative field. The concept of particle motion and center of gravity enables treatment of the motion of a system. There are ample physical problems at the close of each chapter.

Although personally pleased with the organization and content, the reviewer cannot recommend this book for use as a textbook in the first course in engineering mechanics as usually constituted in the United States. The preparation of an engineering sophomore is not such that he can effectively cope with the philosophi-

cal approach of the book in his initial brush with the subject. The book more nearly meets the requirements of a serious course in dynamics given under the auspices of the mathematics, physics, or astronomy departments. This book would be an asset to the library of an engineer. C. R. Mischke, USA

561. Schulz, W., and Ludwig, R., Coordinate systems in the mechanics of flight (in German), *Z. Flugwiss.* **2**, 3/4, 96–104, Mar./Apr. 1954.

Transformation formulas are given for four coordinate systems in common use in the mechanics of flight. The systems are fixed relative to the airplane, the incident air, the ground, and the wind tunnel, respectively. A. R. Mitchell, Scotland

562. Tzénoff, I., General theory of movement of solid bodies in a moving coordinate system (in Serbian), *Godishnik, Univ. Sofia* **47**, sec. 1, part 2, 33–58, 1950/1951–1951/1952.

The three-dimensional motion of a rigid body is analyzed using both a system of moving and of fixed coordinates. Starting with Newton's second law, author proceeds to derive equations of motion of the rigid body in terms of (a) the system of moving coordinates in general, (b) a system of coordinates parallel to the moving coordinates with the origin at any point on the body, and (c) a system of coordinates parallel to the moving coordinates but with the origin at the center of gravity of the body.

Two special cases of the moving axes are considered. In the first, the moving axes are assigned a uniform, rectilinear motion and, in the second, these axes are given an arbitrary motion but the origin is taken at the center of gravity.

The velocities, angular momentum, and inertia forces of the rigid body are calculated with respect to each system of coordinates, the direction and sense of the momentum about any point being established geometrically. It is also shown that the equations for the inertia forces result from a combination of the equations defining the velocities and angular momentum. The author finally applies this theory to the motion of a homogeneous sphere resting on a smooth, horizontal plane. The plane is in turn supported tangent to the earth, which is revolving uniformly about its axis assumed fixed.

From author's summary by J. P. Vidosic, USA

Servomechanisms, Governors, Gyroscopics

(See also Rev. 799)

563. Fuchs, A. M., A bibliography of the frequency-response method as applied to automatic-feedback-control systems, *Trans. ASME* **76**, 8, 1185–1194, Nov. 1954.

564. Leonhard, A., Determination of transient response from frequency response, *Trans. ASME* **76**, 8, 1215–1229, Nov. 1954.

See AMR **7**, Rev. 3470.

565. Oja, V., Frequency-response methods applied to the study of turbine regulation in the Swedish power system, *Trans. ASME* **76**, 8, 1325–1331, Nov. 1954.

See AMR **7**, Rev. 3471.

566. Evans, W. R., The use of zeros and poles for frequency response or transient response, *Trans. ASME* **76**, 8, 1335–1339, Nov. 1954.

See AMR **7**, Rev. 3810.

567. Oldenburger, R., Frequency-response data presentation, standards and design criteria, *Trans. ASME* **76**, 8, 1155–1169, Nov. 1954.

See AMR **7**, Rev. 3118.

568. St. Clair, D. W., Erath, L. W., and Gillespie, S. L., Sine-wave generators, *Trans. ASME* **76**, 8, 1177–1183, Nov. 1954.

See AMR **7**, Rev. 3119.

569. Hall, A. C., Application of frequency-analysis techniques to hydraulic control systems, *Trans. ASME* **76**, 8, 1245–1251, Nov. 1954.

See AMR **7**, Rev. 3122.

570. Oldenbourg, R. C., and Sartorius, H., A uniform approach to the optimum adjustment of control loops, *Trans. ASME* **76**, 8, 1265–1273, Nov. 1954.

See AMR **7**, Rev. 3123.

571. Loeb, J. M., Recent advances in nonlinear servo theory, *Trans. ASME* **76**, 8, 1281–1288, Nov. 1954.

See AMR **7**, Rev. 3124.

572. Pélegrin, M. J., A statistical approach to servomechanisms and regulators, *Trans. ASME* **76**, 8, 1291–1299, Nov. 1954.

See AMR **7**, Rev. 3125.

573. Aikman, A. R., Frequency-response analysis and controllability of a chemical plant, *Trans. ASME* **76**, 8, 1313–1321, Nov. 1954.

See AMR **7**, Rev. 3126.

574. Chestnut, H., Approximate frequency-response methods for representing saturation and dead band, *Trans. ASME* **76**, 8, 1345–1360, Nov. 1954.

See AMR **7**, Rev. 3127.

575. Thomas, C. H., Stability characteristics of closed-loop systems with dead band, *Trans. ASME* **76**, 8, 1365–1380, Nov. 1954.

See AMR **7**, Rev. 3128.

576. Helm, H. A., The frequency-response approach to the design of a mechanical servo, *Trans. ASME* **76**, 8, 1195–1214, Nov. 1954.

577. Bromberg, B. G., Performance operator, ASME Fall Meet., Milwaukee, Wis., Sept. 1954. Pap. 54—F-6, 30 pp.

Author employs the complicated notation of Professor C. S. Draper to treat performance operators relating outputs to the inputs of physical systems. Open and closed loops are considered. Performance operators are given for first- and second-order systems as well as multi-degree systems.

R. Oldenburger, USA

578. Reethof, G., On the dynamics of pressure-controlled hydraulic systems, ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-7, 18 pp.

Hydraulic system, containing constant flow source, pressure control valve, hydraulic motor and load, and compressible fluid, is analyzed under simplifying assumptions. Equations are linearized for small oscillations and resulting fourth-order dif-

ferential equation is made to yield stability criteria by use of Routh's discriminant. L. Becker, USA

579. **Looney, R., A thermal sine-wave generator for speed of response studies,** ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-28, 9 pp.

The investigation of the speed of response of thermal-measuring elements by the frequency-response method requires a sinusoidal input and a record of the periodic input and output. This paper describes a thermal sine-wave generator using water as a fluid and includes frequency-response curves derived from test data. The generator has continuous adjustment of frequency from 0.75 cps to 0.0005 cps at a maximum flow velocity of about $1^1/_2$ fps. The flow velocity past the specimen being tested is adjustable. From author's summary

Vibrations, Balancing

580. **Haag, J., Vibratory motions [Les mouvements vibratoires],** Paris, Presses Univ. de France, 1952, 268 pp. 1540 Fr.

The first 100 pages give a simple and lucid treatment of the vibration of single-degree-of-freedom systems, with various kinds of damping. The rest of the book is more difficult and deals with the movement of single-degree-of-freedom clock mechanisms in which the sustaining and friction forces are nonlinear. First, small nonlinearities are discussed in great detail, then the general theory of pronounced nonlinearities Illustrations of electrical systems and mechanical systems that are not clocks are given from time to time. J. P. Den Hartog, USA

581. **Wasow, W., On singular perturbation problems in the theory of nonlinear vibrations** (in French and English), *Publ. sci. tech. Min. Air,* Paris, no. 281, 207–218, 1953.

In this paper, concerning works of Wasow, Friedrichs, Levinson, Tihonov, and Volk, author considers the question as to the existence and construction of periodic solutions of singular perturbation problems of nonlinear mechanics; that is, problems in which the full differential equation is of higher order than the reduced one, obtained by setting a parameter equal to zero.

The perturbation problem under consideration is of the following form

$$\dot{X} = f(X, Y, Z);\ \dot{Y} = g(X, Y, Z);\ \dot{Z} = (1/\epsilon)h(X, Y, Z) \quad [1]$$

It is interesting that, in contrast to the familiar situation of ordinary perturbation theory, the convergence of the solution to one of the simplified problem as the parameter goes to zero is not to be considered a foregone conclusion in singular perturbation problems. In particular, the solutions are, generally, discontinuous functions of ϵ at $\epsilon = 0$.

In order to establish the existence of periodic solutions of the full equations, one sees, fortunately, that the classical procedure developed by Poincaré for the regular problem can be extended. Considering the equation

$$\epsilon(d^n\mathbf{X}/dt^n) = F[\mathbf{X}, (d\mathbf{X}/dt), \ldots, (d^m\mathbf{X}/dt^m);\ t;\ \epsilon],\ (n > m) \quad [2]$$

one supposes that the reduced equation has a periodic solution $u(t)$ of period T. Setting $\mathbf{X} = u(t) + \sum_{r=1}^{\infty} \epsilon^r y_r$, one finds a periodic solution of [2] $U(t, \epsilon)$ such that $\lim_{\epsilon \to 0} U(t, \epsilon) = u(t)$. Author discusses also singular perturbations of discontinuous solutions. A. Pignedoli, Italy

582. **Liner, H. S., The natural frequencies and modes of vibration of a rotating beam,** *J. roy. aero. Soc.* **58,** 525, 652–654, Sept. 1954.

Author expresses inertia and centrifugal loads acting on rotor blade as a distribution of suitable transverse loads F_j which are linearly related to the displacements y_k at stations x_k (i.e., by a matrix equation). Author suggests solution of the equations for F_j, for various assumed frequencies ω, by matrix iteration or digital computer methods. Plotting of the frequency-response curve locates the natural frequencies. G. Horvay, USA

583. **Leitner, A., and Hiedemann, E. A., Transverse vibrations of a symmetric tapered reed,** *J. acoust. Soc. Amer.* **26,** 4, 509–510, July 1954.

The tapered reed, used in ultrasonic whistles, is a symmetric and homogeneous bar of rectangular cross section, uniform in the center and uniformly tapered to a sharp edge at each end. It is vibrating transversely under free-free conditions in the plane of the taper and in its lowest symmetric mode; i.e., it must be mounted at the nodes. The frequencies and positions of the nodes for such bars have been calculated, combining the exact methods of Rayleigh and Kirchhoff for bars of uniform and tapered cross sections, respectively. The main problem is that of joining the two different solutions at the junction of the two regions. Results were obtained for a representative range of values of the ratio of length of tapered portion to total length. The effect of the surrounding medium has not been considered. From authors' summary

584. **Cox, H. L., Flexural vibration of plates on uniform elastic foundations,** *J. roy. aero. Soc.* **58,** 525, p. 651, Sept. 1954.

Demonstration via matrix algebra of simple relationship between natural frequencies of plates with and without elastic foundations; result is obvious from glance at differential equation. J. M. Hedgepeth, USA

585. **Bolotin, V. V., Parametric excitation of obliquely symmetrical vibrations of elastic arcs** (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **15,** 83–88, 1953.

586. **Okamoto, S., On the bending and the vibration of the arch ring,** Proc. 1st Japan nat. Congr. appl. Mech., 1951; Nat. Committee for Theor. appl. Mech., May 1952, 315–319.

The problem of free and forced vibrations of a circular arch is treated. The effects of shearing forces and rotatory inertia are considered and the more accurate formulas for the relations between strains and stress resultants are used, all with a view to applying the results for the computation of thicker arches (arch dams in case of earthquake). A very illustrative numerical example is added. D. Radenković, Yugoslavia

587. **Brähmig, R., The experimental determination of the natural frequencies of machines on rubber-elastic foundations. Parts I, II** (in German), *ZVDI* **96,** 21/22, 709–714, 747–751, July/Aug. 1954.

Rubber shock absorbers are placed between machines and their foundation for the purpose of absorbing most of the vibratory motion which might otherwise be transmitted to the foundation, to the detriment of equipment and the annoyance of personnel. To fulfill this purpose the rubber shock absorbers must be so designed that the natural frequencies of the mass-spring system represented by machine and absorbers are well outside the operating frequencies of the machine. The natural frequencies are not easily computed analytically with any degree of accuracy because

of the simplifying assumptions necessary to make an analysis possible, particularly that a machine is a rigid body, that rubber is perfectly elastic, and that its dynamic and static moduli of elasticity are the same. Since an accurate knowledge of the natural frequencies is important in the diagnosis of troubles resulting from excessive vibrations, author describes several experimental methods for accurate determination of these frequencies.

Free vibrations can be produced by a single external blow or displacement of the system. This type of test does not, however, reveal the extent of the undesirable frequency range below and above the critical frequencies. A simple test is of the deceleration type: the machine is operated in its working range and then the fuel supply is cut off. This test does not pinpoint the natural frequencies, particularly if dissipative forces cause rather rapid deceleration. Furthermore, operation of the machine can result in the excitation of only some but not all possible modes of vibration. This criticism, the author points out, applies also to tests in which the machine is run, successively, at various speeds. Nevertheless, the latter type of test does allow the accurate determination of at least some critical frequencies. The author favors tests using external sinusoidal excitation. This can be in the form of mass excitation—reaction of a reciprocating mass or centrifugal force resulting from unbalance of eccentrically fixed rotating masses—or the excitation can be caused by slightly displacing some points of the system sinusoidally. The author suggests a third method in this class, namely, external excitation by means of electromagnetic forces.

One series of tests on a diesel-driven generator, using mass excitation, is described. The difference between computed and experimental values for the natural frequencies is found to be of the order of 10–15%.

Reviewer believes that the chief merit of the paper lies in the methodical analysis of the advantages and disadvantages of the experimental methods available for determining the natural frequencies of machines on elastic foundations.

L. Schenker, USA

588. Chen, Y.-N., Torsional vibrations with regard to the mass and damping effect of elastic members (in German), *ZAMP* **5**, 4, 293–316, 1954.

Differential equation governing forced torsional vibration of a motor—electric shaft—propeller system is solved for the case that frictional moments are acting along the shaft and on motor and propeller, while the excitation is by a periodic moment from the motor. A graphical solution by aid of a vector diagram is presented, which can be extended to a system with n masses. Author's remark that no analytic solution is possible if exciting moments are acting at different masses is not clear to reviewer. Author stresses the simplicity of the graphical methods.

A. I. van de Vooren, Holland

589. Fettis, H. E., Corrections and additions to "A modification of the Holzer method for computing uncoupled torsion and bending modes," *J. aero Sci.* **21**, 5, 359–360, May 1954.

590. Béguin, F., Propellers as a source of ship vibrations, *Sulzer tech. Rev.* no. 1, 17–27, 1954.

A concrete example is cited to show that vibrations in ships are not necessarily due to the propulsion machinery, as is often assumed. In the case described, the torsional vibrations which presented themselves in the hulls of two cargo motorships of modern design proved to be due to the cyclic forces of the four-bladed propeller. When the original propeller was replaced by one with five blades, all troublesome vibrations disappeared.

From author's summary

591. Guittard, J., Theoretical study of vibratory motion with obstacles and discontinuities (in French), *Acustica* 3, 1, 22–32, 1953.

Special types of vibratory motion with obstacles and discontinuities can be analyzed by using the powder method and microaneroids, and data thus obtained are amenable to conventional mathematical analysis.

The above statement is valid and applicable to nonperiodic circulation and vortex phenomena which may be extended to include Kundt's striations. The streamlines can be derived from complex potentials and conformal presentation in a two-dimensional space. Examples of such curves from experimental data and theoretical studies illustrate the paper.

The study of the Y junction shows that further assumptions have to be made, particularly in the domain of successive reflections and attenuation of the sound waves—only then can the theoretical results be reconciled with the experimental data.

From author's summary, amplified by S. J. Zand, USA

592. Olsson, C. O., and Orlik-Rückemann, An electronic apparatus for automatic recording of the logarithmic decrement and frequency of oscillations in the audio and subaudio frequency range, *Flygtekn. Försöksanst. Medd.* **52**, 26 pp., Feb. 1954.

An electronic apparatus of automatic evaluation of the damping of a harmonic oscillation has been designed and constructed. The apparatus is based on the idea of representing the harmonic damped oscillation by a rotating vector on the screen of a cathode-ray tube in such a way that the rate of decrease of the length of the vector is a measure of the damping. The results are obtained simultaneously with the oscillation test as two numbers in decimal digits, which are inversely proportional to the logarithmic decrement and the frequency, respectively. The apparatus, which is named the "Dampometer," has been used for some time for free oscillation measurements of the dynamic stability derivatives of airplane models in wind tunnels and has proved to be very satisfactory. It gives results of usually higher accuracy than evaluation methods in common use, and permits a most considerable saving of time.

From authors' summary

Wave Motion, Impact

(See also Revs. 720, 764, 878)

593. Kahane, A., Warren, W. R., Griffith, W. C., and Marino, A. A., A theoretical and experimental study of finite amplitude wave interactions with channels of varying area, *J. aero. Sci.* **21**, 8, 505–524, 565, Aug. 1954.

The theoretical study presents a simple method for calculating the interaction of an isentropic wave with a channel of discontinuous area change which does not require the iterative procedures of the existing methods. By the present method the steady-state conditions after passage of an isentropic wave may be determined from a chart. The chart is useful in the discussion which is presented of the nature of solutions for various initial conditions.

Experiments were carried out in a shock tube to indicate the nature of the actual two-dimensional interaction processes and to test the foregoing one-dimensional calculations. A channel of area ratio 0.504 was made in such a way the wave could be incident on either end. Density fields were measured with the aid of a Mach-Zehnder interferometer. The transient density distributions observed in the center of the channel agree excellently with a one-dimensional theory. The time required for ultimate steady flow to be established was observed for a wide variety of shock strengths, using both the convergent and divergent channels.

The isentropic wave theory fits the measured densities well for weak shocks, and the shock-wave theory agrees satisfactorily with the measured densities for strong shocks.

T. Okamoto, Japan

594. Lunde, J. K., A note on the linearized theory of wave resistance for accelerated motion, "Mémoires sur la mécanique des fluides," *Publ. sci. tech. Min. Air, Paris*, 219–232, 1954.

The general solution for the *accelerated* motions of a ship advancing on a straight path in the middle of an infinitely long shallow rectangular canal has been obtained earlier by the author [*Trans. Soc. nav. Arch. mar. Engrs.*, 1951]. In the present paper it is restated and solutions for important particular problems deduced from it. The author derives:

(1) The boundary condition; (2) using Havelock's method, he establishes the velocity potential for a single source, and (3) for a source-sink system moving in a canal. From (3) the wave resistance for a slender (thin) ship is calculated. As particular cases author derives the resistance (a) when the motion starts from rest with speed c which is maintained constant, (b) the limiting case of (a) for $t \to \infty$ (steady state) yields Sretensky's (Keldysh's and Sedov's) formula, (c) for the motion in a deep canal ($d \to \infty$). Further, the resistance is obtained for motions in *shallow* and in *deep* unrestricted water. In the latter case for c = const, Michell's formula is obtained.

G. P. Weinblum, Germany

595. Riparbelli, C., A paradox in the theory of impact, *J. aero. Sci.* **21, 6, 429–430, June 1954.**

596. Satô, Y., Study on surface waves, XI. Definition and classification of surface waves, *Bull. Earthq. Res. Inst. Tokyo Univ.* **32, part 2, 161–167, June 1954.**

Elasticity Theory

(See also Revs. 551, 589, 600, 605, 611, 612, 618, 619, 621, 642, 649, 763)

597. Lorente de Nó, C., Synthesis of elasticity methods. The elastic body [Synthèse des méthodes de l'élasticité. La pièce élastique], Paris, Gauthier-Villars, 1954, xiv + 217 pp. 2800 Fr.

The concept of the elastic center of an arch and the associated elastic weights was formulated by Culmann (1821–1881). Later, Ritter in his "Anwendungen der Graphischen Statik" (Zurich, 1906) presented "Applications of the graphic statics of Prof. Culmann," which was the first published form of Culmann's work. The introduction of the elastic center simplified the problem of arch analysis because the redundant reactions could then be determined by solving three equations, each containing only one unknown.

The advantages afforded in arch analysis through the use of the elastic center have been incorporated in numerous texts on structural theory. Professor Carlos Lorente de Nó at the University of Madrid prepared in 1952 an extremely comprehensive exposition of Culmann's technique and his notes have been translated into French by Grauz to comprise the present volume. "La pièce élastique" is perhaps the most exhaustive treatment of this phase of classical structural theory available in any language. The volume is divided into three chapters: 1 The study of the elastic arch; 2 The role of strength of materials; and 3 Culmann's work.

In the first chapter, a symmetric arch built in at one end and free at the other is subjected to an arbitrary loading applied at the elastic center, and the various components of displacement are determined. From these results a set of intrinsic equations governing displacements is derived. The moments of inertia of the elastic weights with respect to a set of orthogonal axes appear in these last equations. If the origin of these axes is taken at the elastic center of the arch, and the axes then rotated about this center, the locus of the "elastic radius of gyration" is an ellipse. This is designated as the ellipse of elasticity of the system. Utilizing this concept, the forces at the elastic center required to produce unidirectional displacement or pure rotation of the free extremity of the arch are calculated. Finally, the redundant reactions at the extremity are calculated for an arch built in at both ends and subject to an arbitrary force system. Influence lines for the redundant reactions are also presented. The last section of chap. 1 should be of considerable value to designers, as it presents influence lines for horizontal and vertical displacement as well as angular rotation of an arbitrary point in a clamped-end arch of constant cross section subject to either a horizontal or vertical force or a moment at an arbitrary point on the structure.

The second chapter introduces an equation describing the variation in moment of inertia of the arch cross section which permits an analytic expression of this quantity for a wide variety of arches, merely by varying one parameter in the equation. The particular case of an arch having a parabolic centerline and constant moment of inertia is investigated by use of this expression and the redundant reactions determined for an arbitrary loading on the arch. An arch having a parabolic centerline and a harmonic variation in cross-sectional area is treated analogously. Thermal effects for a symmetrical arch having an arbitrary variation of cross section are investigated in detail. A technique involving successive approximations for the dead-load analysis of a symmetric arch of arbitrary cross section concludes the second portion of the book.

The last chapter introduces the application of Castigliano's first theorem as well as Maxwell's reciprocal theorem to the analysis of arch deformations. The well-known relation between the elastic curve of a structure and the influence line for certain reactions is employed to study an unsymmetrical arch subject to an arbitrary loading. An appendix presents a detailed discussion of the characteristics of the ellipse of elasticity.

"La pièce élastique" presents a very clear and exceptionally detailed exposition of the elastic center-elastic weight technique as applied to arch analysis. The numerous elastic curves and influence lines should make the book valuable to designers. Numerical examples of the application of this theory occur frequently throughout the book. W. A. Nash, USA

598. Ornstein, W., Stress functions of Maxwell and Morera, *Quart. appl. Math.* **12, 2, 198–201, July 1954.**

By two applications of the theorem that a solenoidal field has a vector potential, author expresses the stress components of an elastic body in such a form that the Maxwell and Morera stress functions arise in a more natural way than in the usual ad hoc method of introducing them. In the last equation, $[-1/2)(\partial/\partial z)$ should read $(-1/2)(\partial/\partial x)$; in Eq. (15) the quantities $(W_2 + V_3)$ and $(V_1 + U_2)$ should be interchanged; in Eq. (16) the last W_1 should be U_1. Author refers several times to a matrix as antisymmetric when, in fact, it is not; but this does not affect correctness of final results. Sentence terminating in Eq. (2) is inaccurate. H. D. Block, USA

599. Satō, M., Mean value of pressure generated by freezing of water in a closed container (in German), *J. sci. Res. Inst. Tokyo* **48, 65–70, June 1954.**

The formula derived previously [AMR **7**, Rev. 3337] and ex-

pressing the pressure created during freezing of water in an enclosed cylindrical or spherical container as a function of fraction of radius frozen is integrated over the radius and simply called mean pressure. Reviewer sees no physical significance in this method of averaging. Frequent grammatical errors and non-idiomatic expressions in German are disturbing.

L. S. Dzung, Switzerland

600. Langer, B. F., Working-stress criteria for nuclear power plants, ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-59, 10 pp.

Author proposes a method for combining fluid-pressure stresses and stresses produced by thermal gradients in shell walls. A method of estimating the design factor of safety based on the fatigue life of the material is presented for the combined stress condition in pressure vessel. Author uses the "intensity of stress" (effective stress) with steady-state and variable components in defining the factor of safety from fatigue viewpoint. Discussion of relative importance of ductility, creep, endurance limit, creep-rupture strength, impact strength, and notch sensitivity in reactor design is presented. Reviewer believes that the paper represents a step toward more practical design of pressure vessels when rigorous analysis of pressure and thermal loading is available.

L. W. Smith, USA

601. Tremmel, E., Theory of the slotted annular disk of variable width (in German), *Öst. Ing.-Arch.* **8**, 1, 11–38, Feb. 1954.

The solution of the biharmonic equation expressed in bipolar coordinates was given by J. Krettner in a dissertation (München, 1941). With this fundamental information, Tremmel, using the Airy stress function, obtains the solution to several plane stress problems involving split rings whose boundaries are characterized by eccentric circles. Both symmetric and antisymmetric plane loadings are considered. In the former case, seven constants must be determined from boundary conditions; in the latter case there are three. Stress fields and displacements are obtained for each of the following loadings on a split ring: (a) pure bending; (b) a pair of opposed forces acting normal to the axis of symmetry of the ring; (c) uniform radial pressure around the outer boundary together with a pair of opposed forces each of magnitude sufficient to maintain equilibrium of either half of the ring about its axis of symmetry; (d) a pair of opposed shearing forces, one applied at each face of the slot in the ring. Also the corresponding quantities are obtained for a simply supported arch subject to hydrostatic loading where the boundaries of the arch are described by bipolar coordinates. The elasticity solution obtained is compared with that given by the usual arch analysis.

W. A. Nash, USA

Experimental Stress Analysis

(See also Revs. 631, 775)

602. Hendry, A. W., Photoelastic experiments on the stress distribution in a diamond-head buttress dam, *Proc. Instn. civ. Engrs.* **3**, 3, part 1, 370–396, May 1954.

Paper describes an experimental study of the stress distribution in a diamond-head buttress dam. The gravitational stresses were determined by the "frozen stress" photoelastic method, after the effective density of the model material had been raised by rotating the model in a large centrifuge. The hydrostatic stresses were found separately by the same method; the loading in this case was applied by a battery of small hydraulic rams. The gravitational and hydrostatic loads were combined to give the stresses in the dam when full. An analysis of the stresses in the model was carried out, using the method of calculation adopted for the actual dam, and the results were compared with those obtained experimentally; reasonable agreement was obtained.

The stresses within the diamond head were examined by slicing the frozen stress models and by further tests on two-dimensional models. These were carried out to investigate, in particular, the effect of various holes passing through the head.

From author's summary

603. Coiley, G. M., Stress concentration in swept wing panels using photoelastic models, *Coll. Aero. Cranfield Rep.* no. 78, 28 pp., Mar. 1954.

Purpose of this paper is to compare theoretical solutions for swept-wing stress concentrations with photoelastic tests of swept-wing panels. The peak shear stresses found experimentally were found to agree with theoretical predictions in that, for large values of the wedge angle, the stresses were considerably greater than for the case with no sweep, and for small angles the stresses were smaller.

Values obtained for direct stress in the free edge at the apex of the wedge show that the theoretical solution becomes invalid for angles of sweep equal to 129°; for angles larger than 129°, the stresses do not change signs but become large.

C. B. Matthews, USA

604. Kuhlmann-Wilsdorf, Doris, A new method for measuring small changes in length (in German), *Z. angew. Phys.* **6**, 4, 171–174, Apr. 1954.

Solution of measuring problems, such as encountered with the effects of magnetostriction and plastic or elastic changes, is suggested by introduction of a relatively simple mechanical instrument. The basic components consist of a miniature cylinder suspended between two vertically arranged tapes and a miniature mirror with c.g. on the cylinder axis. The cylinder features two sections with slightly different diameters, on which one end of each tape is fastened and partially rolled up, while the other ends are fastened to the opposite points of the unit to be measured. The mirror serves as torsional pickup by reflecting a light beam which registers any change in radial displacement of the cylinder, resulting from change in distance between the two points.

Since it is feasible to make the basic mechanism from the same material as the investigated one, the influence of ambient conditions can be eliminated. The simplicity of this method permits its utilization for improvised laboratory setup as well as base for design of a permanent instrument with high accuracy. The paper presents thorough treatment of the subject.

C. R. Bell, USA

Rods, Beams, Shafts, Springs, Cables, etc.

(See also Revs. 582, 583, 586, 623, 626, 634, 635, 658, 667)

605. Zimmermann, K., Long rail and jointless track. Parts I, II, III (in German), *Dtsch. Eisenbahntech.* **2**, 1, 2, 4; 3–7, 61–63, 139–145, Jan., Feb., Apr. 1954.

Author considers temperature stresses and resultant rail expansion. Theoretical investigations backed by test results show that friction between rail and ties limits expansion to rail ends while center portion is unaffected between −25 and +55 C. Stresses increase from zero at rail end to maximum at center. Effect of tie friction reduces total expansion to one half of that of a free rail. Similar considerations apply to rails restrained by tie

and fish plate friction. To control rail stresses and expansion, 15 and 30-m rails are installed in ambient temperature range of −14 to +26 and −6 to +20 C, respectively. Limitation of expansion to rail ends only encourages the step from long rails to jointless track. By 1952 some 650 miles of track had no rail joints except at switches and due to track (signal) insulation.

Experience with 60, 120 and 1000-m jointless sections are encouraging, and author considers most suitable types of rail fastenings with particular reference to reduced steel requirements, ties, and tie arrangements. Particular importance is attached to low-temperature considerations with regard to rail fracture and resultant gaps of 0.75 to 6 in. At present, jointless track rails are joined at ambient temperature of +10 to +15 C at which rail stresses will be zero. Maximum compressive stresses (at +55 C) will be limited to about 74 t, at expense of high tensile stresses in winter. Since consequences of high compressive stresses (buckling) can be eliminated, while fractures at low temperatures cannot be checked, it is for consideration whether the neutral (installation) temperature range should be reduced to limit size of possible low temperature fractures to 0.75 in. Author suggests extensive experimentation with jointless track installed at various neutral temperature ranges to study effect of high and low ambients on rail stress.

Attention is also drawn to the necessity for rails and ties to form a continuous well-embedded framework.

J. L. Koffman, England

606. Higgins, T. R., and Ruble, E. J., Structural application of high-strength bolts, *Proc. Amer. Soc. civ. Engrs.* **80,** Separ. no. 485, 1–10, Oct. 1954.

607. Kaehler, P., On the spontaneous compensation of the bending load of screws with slanting support surfaces (in German), *Forsch. Geb. Ing.-Wes.* (B) **20,** 4, 113–119, 1954.

When clamping screws are supported on faces which are not perpendicular to the axis of the screw bolt, a bending stress is exerted. If the ensuing lateral torques are larger than the frictional torque in the support, a compensating movement occurs which automatically reduces the bending moment. These phenomena can be followed for various conditions by the calculation and this gives important information for the optimum selection of the dimensions of the screw, the surface finish, and the necessary locking devices. The spontaneous compensation can be favored by having a small coefficient of friction in supporting surfaces. With increased stiffness of the screw, bending stress is reduced. Optimum value is obtained when compensating movement is spontaneous with moment when the screw makes full contact.

Additional advantage of a small coefficient of friction is reduction of torque stress during tightening. Supports having a small coefficient of friction can frequently replace spherical supports. Locking devices should be favorably arranged between nut and bolt and not between nut and support when small stresses in screw bolt are desired. P. Grodzinski, England

608. Bárány, J., The classification and influence of the crown gear of bevel gears on technology and on dimensioning in respect to shape and strength, especially of spiral gearing (in Hungarian), *Gép* **5,** 6, 281–286, 15 figs., 1 tab., 1953.

Crown gears are related in the same way to bevel gears as racks are to spur gears. The pitch cone angle of crown gears is 90°; the "pitch line plane" of "ideal" crown gears coincides with their "base plane," and the vertex of the generating lines of the teeth coincides with the point of intersection of the "base plane" and the axis of the gear in this type of crown gear. In "approximate" crown gears the pitch line plane and base plane do not coincide. Either type crown gear can be of the "central" or "corrected" design. Each can have a "whole number" or a "decimal fraction" (imaginary) number of teeth. Straight profile generating tools can be considered as a tooth of a crown gear. The Reinecker-Bilgram straight and helical bevel gear generator operates on the ideal crown gear principle, while other types (Heidenreich-Harbeck, etc.) are based on the approximate crown gear. Klingelnberg, Oerlikon, and Fiat spiral bevel gear generators work on the ideal crown gear principle and Gleason spiral bevel generators on the approximate crown gear. The calculation of gears differs according to the type of the crown gear; the generally valid deduction as well as an example for computing a straight and a spiral bevel gear are presented in the article.

Courtesy of Hungarian Technical Abstracts R.E.

609. Botstiber, D. W., Manufacturing methods of power-transmission gears and their influence on design considerations, ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-19, 10 pp.

Plates, Disks, Shells, Membranes

(See also Revs. 584, 601, 641, 661)

610. Aggarwala, B. D., Singularly loaded rectilinear plates —I, *ZAMM* **34,** 6, 226–237, June 1954.

The problem of a rectilinear plate under a concentrated load is treated in a general manner. The plate is mapped onto a half space by the Schwartz-Christoffel transformation; then, by using a vortex analog, closed form solutions for the vertical shearing forces are obtained in terms of Weierstrass elliptic functions. The rectangular and triangular plates are considered in detail and numerical values for various points in each case are computed. The deflection for a regular polygonal plate is obtained and evaluated at the center. These values compare closely with existing solutions. This method has the special merit of avoiding the use of series of doubtful convergency. T.-T. Loo, USA

611. Koiter, W. T., and Alblas, J. B., On the bending of cantilever rectangular plates. I, *Proc. k. Ned. Akad. Wet. (B)* **57,** 2, 250–258, Mar./Apr. 1954.

Authors are concerned with a rigorous solution to the problem of bending in a cantilever plate. The plate is assumed to be loaded in two different ways, namely, by a uniform distribution of loads over its width and by a uniformly distributed bending moment over its transverse free edge. The assumption of a semi-infinite strip is made. This simplification is shown to be valid if the width of the plate does not exceed its length.

In the solution, however, difficulties due to singularities in the corners of the strip where the clamped edge intersects the free edges warranted an exact solution to a secondary problem, i.e., the problem of an infinite wedge plate, one edge of which is rigidly clamped and the other edge free but loaded by a distribution of bending moments. It is with this secondary problem that parts I and II of the paper are concerned.

Basic equations, boundary conditions, and loading for both the strip problem and rectangular wedge problem are given in this part of the paper. The formal solution is then obtained for the rectangular wedge plate by means of Fourier transforms. Resulting solution for the deflection is in the form of a Mellin integral. Authors point out that a more direct and simple solution may be obtained by means of a Mellin transform, but the solution by Fourier transforms was used because a similar method will be applied to the strip problem. R. E. Heninger, USA

612. Koiter, W. T., and Alblas, J. B., On the bending of cantilever rectangular plates. II, *Proc. k. Ned. Akad. Wet.* **(*B*) 57, 2, 259–269, Mar./Apr. 1954.**

Verification of the formal solution for deflection of the rectangular wedge plate of part I is made. Formulas for the root bending moment, the reduced shear force along the clamped edge, and the torsional moment along the free edge are given. Results are presented illustrating the oscillating behavior of the above moments and shear force and also the essential singularity in the stress distribution at the corner of the plate. A condensed version of the authors' discussion on the singularity in the corner of the plate follows:

(1) The singularity is strongly dependent on the value of Poisson's ratio. (2) The approximate character of plate theory is too crude in the region near the corner because the shear forces are unbounded. (3) The singularity is not removed or even reduced by the application of a more refined plate theory, i.e., Reissner's theory. (4) The explanation of the singularity must not be sought in the approximate character of plate theory but in the intersection of a free and rigidly clamped boundary.

R. E. Heninger, USA

613. Chankvetadze, G. G., Bending of a circular plate resting on several points (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **14, 73–80, 1953.**

Muskhelishvili has simplified the solution of complicated problems in the plane theory of elasticity by means of functions of a complex variable [AMR **7**, Rev. 2099].

Present paper shows application of Muskhelishvili's method to the bending of a circular plate under uniform load and simply supported in several points of its contour. Elegant and simple solution is given in a closed form. Some numerical results are compared with those obtained by S. P. Timoshenko in his "Theory of plates and shells."

Paper is of interest for engineers, who can easily follow all theoretical deductions. V. Vodička, Czechoslovakia

614. Delaney, A. L., Shell structures, *J. Boston Soc. civ. Engrs.* **41, 4, 405–417, Oct. 1954.**

Author's purpose is to try and explain the behavior of barrel shells and to compare its action with other structural elements in common use by the average designer.

Almost all of the past literature on shell structures deals exclusively with the mathematical aspects of its design while neglecting to explain the geometrical and physical relationships involved. As a result, the simplicity with which shells function has been obscured. From author's summary

615. Rüdiger, D., Contribution to the boundary distribution theory of circular cylindrical shells (in German), *Ing.-Arch.* **22, 3, 160–162, 1954.**

On the basis of articles by W. Zerna [title source **20**, p. 357, 1952] and H. Neuber [*ZAMM* **29**, p. 97, 1949], author solves the differential equation $\Delta^4\phi + (1 - \nu^2)/k \cdot \phi^{IV} = 0$ for the stress function Φ of the cylindrical shell. Supposing ϕ to be of the form $e^{\sqrt{m+1}\lambda\varphi} \cos \lambda\xi$, he solves the corresponding characteristic biquadratic equation $m^4 + (1 - \nu^2)/\lambda^4 k = 0$ for m and obtains $(m + 1)^{1/2} = \mathfrak{K} + i\mu$, where $\mathfrak{K}$, μ depend on $\epsilon = \lambda[4k/(1 - \nu^2)]^{1/4}$ only. Explicit expressions for stresses, moments, and strains are given (for $\nu = 0$).

Reviewer would have liked to see the above characteristic equation compared with the corresponding equation of Flügge in order to show the order of the differences between the two methods. M. Hampl, Czechoslovakia

616. Estrin, M. I., One method for the solution of a homogeneous problem for a symmetrically loaded toroidal shell (in Russian), *Prikl. Mat. Mekh.* **17, 3, 619–622, Sept./Oct. 1953.**

Solution of the homogeneous problem for the symmetrically loaded toroidal shell reduces to the solution of an ordinary second-order differential equation with periodic coefficients. By appropriate substitution, the equation is reduced from three to two terms, and further simplified because of the relative smallness of one of the parameters.

The author then uses Hill's method for representing the periodic coefficient in the form of an infinite sum and indicates the procedure in finding solutions of the original equation. The work is concluded with the investigation of a particular problem in which the ratio of the radii is very small. It appears the original equation has a typographical error. S. Sergev, USA

617. Alumyae, N. A., Determination of the state of equilibrium of a circular shell with axially symmetric load (in Russian), *Prikl. Mat. Mekh.* **17, 3, 517–528, Sept./Oct. 1953.**

In this work, axially unsymmetrical states of equilibrium of cylindrical shells of revolution under action of external hydrostatic pressure and axial load are investigated. It is assumed that in the symmetrical stressed state—with sufficiently small loads—the stresses due to axial loads will be smaller than or of same order of magnitude as stresses caused by external pressure.

Fundamental relations and equations of nonlinear theory of local instability without bending stresses in the shell are derived. Upon clarification of asymptotic properties of integrals of appropriate equations, there is derived an ordinary differential equation of fourth order, and a simple variational equation is given for determining the critical load. It is shown that consideration of edge effects in axially symmetrical stressed state gives an insignificant correction to the critical load for the thin-walled shells when the critical load is determined from the stress state without bending.

The character of deformation determined by the critical load is assumed to apply to the first part of the postcritical stage, and simplified equations are derived for its investigation. These equations give good results for the case when ratio of thickness to radius of curvature of middle surface is small.

The work is devoted principally to study of the axially unsymmetrical forms, the symmetrical forms being used as a basis of comparison. S. Serger, USA

618. Bölcskei, E., Deformation of thin shells (in Hungarian), *Magyar Építőipar* **2, 3, 93–100, 5 figs., 1953.**

Author establishes general principles in relation to the deformation of thin shells applicable to any type of surface and load. The stress distribution in thin shells and its solution by stress functions are dealt with in the first place. Unit strains and unit distortions are defined in terms of position vectors and displacement functions. The deformations and displacement of the shell surface are unequivocally defined by the differential equations thus deduced. The displacement functions are established for inner stresses, changes of temperature, and the settling of supports; the method is used to calculate the deformations of various statically determined shell types. The method is readily applicable to statically undetermined shells as well.

Courtesy of Hungarian Technical Abstracts Z. Sz.

619. McComb, H. G., Jr., Stress distributions caused by three types of loading on a circular semimonocoque cylinder with flexible rings, *NACA TN* **3199, 54 pp., Sept. 1954.**

The cylinder, infinite in length, has along its generators equally spaced stringers carrying only normal forces. The equally spaced

ribs carry normal forces (for which they are infinitely stiff) and in their planes, which are normal to the generators, bending moments. The skin fields between these stringers and ribs carry only shear stresses. This structure, which is enumerable infinitefold statically indeterminate, is analyzed for three types of loading among which are an external unit load in stringer direction, applied at the intersection of a rib, and a stringer. Exact solutions are obtained.

By means of these solutions, the perturbation in the stress distribution may be calculated if in the structure, carrying a certain load, a cutout is made with reinforcing elements in the neighborhood of the cutout.

Author has dealt previously with a special case, viz., the flat skin-field stringer-rib combination ($R = \infty$), in AMR **7**, Rev. 62.

J. P. Benthem, Holland

620. Mathews, R. L., and Horvay, G., Torus analysis, *KAPL Rep.* no. 1072, 37 pp., Feb. 1954.

A 60-in.-diam torus (a continuous hollow piston ring) is made of steel tubing with a $^3/_8$-in. tube diam and a 10-mil wall thickness. It is used to restrict liquid sodium flow in the rotating plugs assembly. A design problem arises. (a) What is the maximum radial compression of the continuous torus, by forces applied on the outside equator, which does not cause permanent deformations? (b) How does the deformation of a slit torus, restrained from shrinkage along the inner equator and squashed by forces applied on the outside equator, compare with the above? The possibility of buckling is to be ignored in these considerations.

For simplicity of analysis, the continuous torus may be replaced in the calculations by an equivalent torus of square cross section. The answers so obtained are estimated to be reliable within 15%. For the slit torus, figures are given both for circular and for square cross sections. From authors' summary

621. Rózsa, M., Differential equations of bent grids (in French), *Acta Techn. Hung. Budapest* **8**, 3/4, 277–293, 1954.

Paper deals with close-mesh grids subject to flexure and demonstrates that these can be replaced by plane plates of similar form without disturbing the conditions of equilibrium, so that the deflections of the two structures will also be identical. The substituted plate is, in general, anisotropic; in some cases, orthotropic or isotropic.

The present paper investigates also orthogonal grids and rhombic and triangular grids as well.

From author's summary by S. C. Das, India

622. Kostyuk, A. G., Calculation of the profile of a rotating disk under creep conditions (in Russian), *Prikl. Mat. Mekh.* **17**, 3, 615–618, Sept./Oct. 1953.

The theory of plasticity as given by A. Ilyushin [AMR **2**, Revs. 731, 1503; **3**, Rev. 1263] is applied to stationary creep in a rotating disk of variable thickness h. The equation of compatibility for creep rates in radial and circumferential directions together with flow conditions is integrated, yielding a nonlinear integral equation for the two stress components. In this equation author makes the arbitrary assumption (stated to be due to A. Ilyushin) that the circumferential stress shall be a fixed numerical proportion of the effective stress, thus arriving at explicit expressions for radial stress and effective strain rate as functions of the radius vector r. Subsequently, the corresponding functional relationship between h and r is taken from the equation of equilibrium. In the special case of constant effective strain rate, independent of r, explicit solutions are obtained. The case of constant temperature and a power law for the relationship between effective stress and strain rate leads to closed expressions for stress and thickness as functions of r. F. K. G. Odqvist, Sweden

Buckling Problems

(See also Rev. 644)

623. Biggs, J. M., Buckling considerations in the design of steel beams and plate girders, *J. Boston Soc. civ. Engrs.* **41**, 4, 418–447, Oct. 1954.

624. Van Der Maas, C. J., Charts for the calculation of the critical compressive stress for local instability of columns with hat sections, *J. aero. Sci.* **21**, 6, 399–403, June 1954.

Calculations are performed according to the principle of moment distribution established by Lundquist, and results are presented in four charts. Author states that the charts can be used to calculate the critical compressive stress above the elastic range by applying Stowell's plasticity correction factor to the case of a hat section. This technique is probably appropriate for design purposes. Stowell factor is given incorrectly here (Eq. 2); it should be multiplied by E_{sec}/E.

K. Washizu, Japan

625. Seide, P., Comments on "Ripple-type buckling of sandwich columns," *J. aero. Sci.* **21**, 4, 282–286, Apr. 1954.

626. Matildi, P., On the calculation of axially compressed bars in an elastic medium (in Italian), *Atti. Ist. Sci. Costr. Univ. Pisa* no. 28, 9 pp., 1953.

In continuation of an earlier paper [AMR **7**, Rev. 444], the buckling load P_{cr} of axially compressed bars in an elastic medium is discussed. The real minimum values of P_{cr} with an integer number of half waves are represented as a family of tangents of the parabolic idealized Engesser solution $P_{cr} = 2 \cdot (EJ\beta)^{1/2}$. Tables are given without and with taking into consideration the influence of shear deformation. F. Stüssi, Switzerland

627. Kuranishi, M., On some influences of imperfections of bars and plates on their buckling properties, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 75–80.

Author investigates the lateral deflections of bars and plates with coexistence of load eccentricities and initial small deflections to establish a satisfactory explanation to the phenomena of reversals and rereversals of deflection that are frequently observed during buckling tests.

Second part of the paper deals with the effect of reduction in apparent stiffness of bars having initial deflection or load eccentricity. Author treats this reduction in stiffness as an apparent tangent modulus and shows how the buckling load of a simple truss is reduced due to initial imperfectness.

T. H. H. Pian, USA

628. Guess, A. L., Stability of a semiflexible duct system, *J. aero. Sci.* **21**, 8, 570–571, Aug. 1954.

629. Yoshimura, Y., Local buckling of circular cylindrical shells and scale effects, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 69–74.

This paper is an extension of the author's previous paper [*Rep. Inst. Sci. Techn. Tokyo Univ.* **5**, no. 5, 1951]. Author restates his argument that the buckling of circular cylindrical shells may occur only locally and proves, by energy consideration, that the buckling stress can no longer be evaluated by the thickness-radius ratio alone but is dependent also on the length of the cylinder. Con-

clusions on the scale effects are: (a) Under constant thickness-radium ratio and a fixed length, the buckling strength increases with the increase of radius or thickness; (b) under constant radius and constant thickness, the buckling strength decreases with the increase of length; (c) strengths of geometrically similar cylinders are independent of their size. T. H. H. Pian, USA

Joints and Joining Methods

(See also Revs. 637, 643, 673, 861)

630. Pöschl, H., Joining elements in metal constructions of small dimensions [Verbindungselemente der Feinwerktechnik] (Konstruktionsbücher, Bd. 14), Berlin, Springer-Verlag, 1954, v + 108 pp., 741 figs. DM 13.50.

In preface author states that literature in this field is desirable owing to the growing importance of these elements in the German industry. The book is written to excite an individual and constructive way of thinking, to be a stimulant for the constructor, and an introduction in the field for the student. Therefore the book gives only fundamental examples of different joining elements and joining methods and is not to be considered as a compilation of recipes.

A large part of the book is devoted to screws, rivets, pressure joints, and welding. For these topics some elementary formulas are given for computation of dimensions, stresses, or ultimate loads, etc.

The book presents no novelties but is carefully written.
E. Steneroth, Sweden

631. Wilkins, E. W. C., and Jessop, H. T., A photoelastic-fatigue programme of experimental research in connection with bolted joints, *J. roy. aero. Soc.* **58,** 522, 435–438, June 1954.

Tests are to be conducted to correlate three-dimensional photoelastic data with fatigue data on metallic specimens. The variables to be considered are: material properties, dimensions, fit of bolt, clamping effect, and kind of joint. Preliminary photoelastic tests have been made to determine the shape of both the photoelastic specimens and the fatigue specimens for some of the tests. N. C. Costakos, USA

632. Schijve, J., The fatigue strength of riveted lap joints and pin-hole joints (in Dutch), *Nat. LuchtLab. Amsterdam Rap.* M. 1952, 42 pp., May 1954.

A survey is given of the fatigue strength of riveted lap joints and pin-hole joints. The stress-concentration factor, the fatigue-strength reduction factor, and their mutual relation are discussed briefly. Proposals for further investigation are mentioned.
From author's summary

633. Cramer, R. E., and Jensen, R. S., Tests of electric flash butt-welded rails, *Bull. Amer. Rly. Engng. Assn.* **55,** 514, 684–697, Feb. 1954.

Structures

(See also Revs. 551, 585, 586, 597, 603, 658, 665, 674, 870)

634. Cowan, H. J., Losses in prestressed concrete beams, *Engineer, Lond.* **198,** 5136, 5–7, July 1954.

Author utilizes equilibrium of forces and compatibility of strains to derive equations for concrete and steel stresses in pretensioned and posttensioned beams, both at transfer and after creep has occurred. Several illustrative examples are worked.
H. Simpson, USA

635. Full-scale test on prestressed concrete beam: 55-ft. span beam loaded to destruction, *Engineering* **177,** 4613, 815–817, June 1954.

An I-shaped beam 30 in. deep, posttensioned with Macalloy bars (grouted) and designed for 444 kip-ft total moment, was tested to failure under concentrated symmetrical loads 6 ft apart. Beam failed at 2.0 times the total design moment (2.4 times the design live load), this being about 7% under the estimated ultimate based on plastic theory and a tension failure. Failure was by crushing of concrete at a load point after development of well-distributed tension cracks. Effective modulus of elasticity calculated from deflections agreed with values from cubes. Calculations showed that in 48 days prestress had dropped 14.5% from the initial 42 British tons psi. P. M. Ferguson, USA

636. Robertson, R. G., Prestressed concrete beams: the economical shape of section, *Proc. Instn. civ. Engrs.* **3,** part 3, 1, 242–247, Apr. 1954.

637. Toprac, A. A., An investigation of welded rigid connections for portal frames, *Welding J.* **33,** 1, 40s–56s, Jan. 1954.

Tests of eleven typical knees used in welded single-span steel rigid frames, with evaluation of each type and suggestions for improvement. From author's summary

638. Major, A., New systems of prefabrication of industrial hall structures, *Acta Techn. Hung. Budapest* **8,** 1/2, 3–23, 1954.

The systems of prefabrication described in this paper are the results of efforts to expedite the erection of halls, workshops, storehouses, and other industrial buildings of that type. Two systems of prefabrication are described here, one of them representing partial prefabrication with traveling, i.e., rolling, scaffolding; the other, total prefabrication, developed on basis of the latter.
From author's summary

639. Hruban, K., Flexure analysis of transfer surface and its application in hall construction (in German, with English, French, and Russian summaries), *Acta Techn. Hung. Budapest* 7, 3–4, 425–464, 1953.

640. Baer, O. A., A strain balance system for analysis of redundant structures, *Proc. Amer. Soc. civ. Engrs.* **80,** Separ. no. 86, 1–7, Oct. 1954.

641. Whitehead, L. G., and McQuillin, L. A., The centre of shear for sections bounded by two circular arcs, *J. roy. aero. Soc.* **58,** 518, 138–139, Feb. 1954.

642. Walker, P. B., Records of major strength tests, *Aero. Res. Counc. Lond. Rep. Mem.* 2790, 5 pp., July 1949, published 1954.

The strength attained in major strength tests, made over a period of ten years, is given for 24 wing systems and ten fuselages. A preliminary analysis is also presented from the standpoints of safety and design efficiency. One third of all the wing systems tested are found to be seriously understrength as originally designed, and it is concluded that wing and fuselage testing for all new types is essential for safety. The majority of understrength aircraft, however, were brought up to the required standard by local strengthening, and it is concluded that this has an important bearing on design efficiency. From author's summary

643. **Editorial, Twenty-five years of nailed structures. Tests on high-strength-steel nails in different wood species** (in German), *Holz-Zentralblatt* **80,** 1/2, p. 4, Jan. 1954.

In line with the U. S. trend to use bright or hardened (heat-treated and tempered) high-carbon-steel nails for fastening or assembling hard woods, comparative tests were performed in Germany on the effectiveness of high-strength-steel nails in woods of a relatively wide strength range.

The presented test data indicate that the stronger wood can take better advantage of the high-strength-steel nail than the weaker wood.

The manufacture of high-strength-steel wire nails is recommended, since these wire nails are more effective than rectangular or square high-strength-steel cut nails available in Germany.

E. G. Stern, USA

644. **Kerekes, F., and Hulsbos, C. L., Elastic stability of the top chord of a three-span continuous pony truss bridge,** *Iowa Engng. Exp. Sta. Bull.* no. 177, 77 pp., June 1954.

The major part (pp. 1–51) of this paper is devoted to an exposition from first principles of the series and stiffness criteria of stability invented by Lundquist [*NACA TN* 617, 652] and rigorously proved by Hoff [*J. aero. Sci.*, Jan. 1941]. The criteria are derived from the extension of the Cross method of moment distribution to the analysis of continuous members subjected to axial loads. In the second part of the paper (pp. 52–77), these criteria are applied to the title problem.

The paper is clearly written. Many of the derivations are of a more general nature than the original and some are entirely new. The particular problem treated in the second part does not seem to have been studied before. Apart from these items, the paper does not contain really new basic ideas.

The frame of hypotheses used is somewhat restrictive: buckling is supposed to take place in the elastic domain; the primary deformations of the top chord normal to the plane of the truss are neglected; the effect of the diagonals and the rotational restraint offered by the verticals also are neglected.

Reviewer thinks that the first hypothesis widely restricts the generality of the method because, for economic reasons, the rigidity of the tranverse frames of the bridge is nearly always chosen so as to produce buckling beyond the proportional limit. Concerning hypothesis two, the study made by Schibler has demonstrated the important effect of the primary deformations of the top chord [see *Mitt. Inst. Baustat., ETH Zürich*]. Concerning hypothesis three, a procedure is presented in the paper to determine the elastic constants for the inclined and post member in terms of the horizontal projection of the member. A similar procedure could be used to include the effect of the other diagonal web members in the stability analysis.

Ch. Massonnet, Belgium

645. **Vincent, G. S., Aerodynamic stability of suspension bridges. Extended studies: logarithmic decrement field damping, prototype predictions, four other bridges,** *Univ. Wash. Engng. Exp. Sta. Bull.* 116, part V, 104 pp., June 1954.

Material is given which ties together special features not considered in earlier reports. Damping of suspension bridges is considered in detail. Attempt is made to show how research results (of entire series of studies) can be applied to design and investigation of suspension bridges. Analysis is made of four existing structures to show method of application.

Reviewer believes the principal contribution of this work must be considered along with the other four parts. Together they probably constitute the most thorough investigation of suspension bridges under the action of aerodynamic forces which is to be found.

F. L. Castleman, Jr., USA

646. **Naruoka, M., and Yonezawa, H., On the design bending moment of reinforced concrete slab of steel highway bridges due to wheel load,** *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 337–342.

In this study of Japanese specifications for steel highway bridges (1939), the specified design procedure for reinforced-concrete slabs is compared with the results of theoretical computations based on theory of elasticity. Three types of rectangular slabs of uniform cross section are considered: (1) A simple supported slab; (2) a cantilever slab; and (3) a four-span continuous slab. Calculations based on the specifications and on the theory of elasticity are compared in graphs and tables. It is concluded that the equations specified for simple supported and cantilever slabs give much larger moments than those indicated by the theory of elasticity; for continuous slabs, positive moments are in fair agreement with the elastic values, but the agreement is poor for negative moments.

I. M. Viest, USA

647. **Hewes, L. I., and Oglesby, C. H., Highway engineering,** New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1954, xi + 628 pp. $8.

This volume covers all aspects of highway engineering, beginning with traffic counts and economic considerations in selection of a route and ending with the maintenance of a completed highway. The impossibility of treating at length all such aspects in one volume is met by giving well-selected bibliography references throughout the text. The authors show how various problems in highway engineering are met by various highway departments and how these numerous approaches have been developed. The book is well suited for a text in a general course in highway engineering. Such a course is usually supplemented by others for those students who select transportation as their field. Among these, Route Surveys, for instance, treats the problems of design of highway alignment and grades, methods of surveys, and computation of earthwork in much greater details. Up to date, this book is the only comprehensive and authoritative treatment of the subject published in one volume.

M. V. Smirnoff, USA

648. **Walls, J. H., Houbolt, J. C., and Press, H., Some measurements and power spectra of runway roughness,** *NACA TN* 3305, 27 pp., Nov. 1954.

Measurements of actual runway roughness obtained by a profile-survey method (engineer's level) are presented. Data were obtained from a survey of a relatively rough runway and a smooth runway. The results of this study are presented as roughness profiles of the runways surveyed and in the form of power spectra.

From authors' summary

649. **Leliavsky, S., Gravity dam deflections,** *Engineer, Lond.* **198,** 5137, 41–45, July 1954.

A formula for gravity dam deflections including only two factors appears to furnish reasonably consistent results. Information on low value of Young's modulus in dams is discussed.

J. C. Geyer, USA

650. **Hammond, J. J., Basic design criteria for concrete gravity and arch dams,** *J. Amer. Concr. Inst.* **25,** 8, 657–668, Apr. 1954.

Paper presents the conclusions reached by a committee of eleven top members of the Bureau of Reclamation design and construction force. The following aspects are analyzed: (1) Forces that act on gravity and arch dams to promote instability or failure; (2) resisting forces which promote stability; (3) meaning and

measurement of safety factor; and (4) required strengths of materials and foundations and the methods of measurement.

A system of design is developed and design criteria for concrete arch and gravity dams are included. J. A. Cheney, USA

651. North, M., Research into the design of horizontally corrugated grain silos, *J. Instn. Engrs., Austral.* **26,** 1/2, 2–8, Jan./Feb. 1954.

Paper outlines briefly a number of original observations made during engineering research in connection with the testing of grain silos manufactured from corrugated galvanized steel sheets. Research is still being carried out on many problems associated with the theoretical design of this form of silo, as it will be seen that available methods of approach to this particular problem are incompatible with results in silos under test.

From author's summary

652. Davies, P. O. A. L., Some aspects of the design of research circulating water tunnels, *J. Instn. Engrs., Austral.* **26,** 6, 115–119, June 1954.

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 622, 663, 685, 858)

653. Jaoul, B., Contribution to the study of plastic deformation (in French), *Publ. sci. tech. Min. Air, Paris* no. 290, 86 pp., 1954.

The stress-strain behavior of metals, particularly of polycrystalline aluminum and aluminum alloys, is investigated. After a short survey of general description and theory of plastic deformation, a quantitative analysis of stress-strain curves in uniaxial tension experiments is given. Following mainly his own previous work, author supposes that the stress σ depends on the plastic strain ϵ for smaller values of ϵ according to a parabolic relation $\sigma = \sigma_0 + A\epsilon^m$. Beyond a critical strain, called the transition point by the author, this function has to be replaced by another parabola with different constants σ_0, A, and m. Experimental investigations concerning the influence of temperature and especially of different impurities on the location of this transition point, and theoretical discussions about the physical meaning of the transition point are the main subjects of the paper. At the end, more complicated states of stress are treated.

This booklet presents a valuable survey of many details of the stress-strain behavior. The reviewer feels, however, that for the physical interpretation of stress-strain curves of polycrystalline material, the curves of single crystals should be considered more thoroughly than is done in this work, particularly since these curves are now well known for all orientations, at least for aluminum. K. Lücke, USA

654. Mahncke, H. E., and Tabor, W., A demonstration of Bingham-type flow in greases, First Ann. ASME-ASLE Conf., Baltimore, Md., Oct. 1954. Pap. 54—LUB-16, 13 pp., 12 figs.

Authors regard a grease as a Bingham body. They describe an ingenious piston-operated gadget for producing velocity profiles of grease pushed through a tube. Brass tubes holding the distorted boundary were cooled to stiffen the grease before splitting the tubes in half. Each half of a tube then exhibits a profile of the flow pattern.

Evaluation of data obtained with a diester oil thickened with a lithium soap, which was propelled at a mean rate of flow of about 30 cm/sec, shows that the Bingham equation is an approximation to the flow condition. R. Schnurmann, England

655. Barlow, D. A., Yield criteria and the bending of wide beams, *J. Mech. Phys. Solids* **2,** 4, 259–264, June 1954.

The ductility of aluminum alloys in bending is discussed. Bend tests on narrow and wide rectangular specimens are used to distinguish between various combinations of yield and fracture criteria for estimating the fracture ductility in plane strain. It is suggested that the various alloys have different criteria; however, a more accurate check is required before this can be stated with certainty. Marshall Holt, USA

656. Thomas, T. Y., On the rotation of grid lines produced by the formation of plastic bands in tension tests, *Proc. nat. Acad. Sci. Wash.* **40,** 6, 401–407, June 1954.

Implications of author's theory of necking in flat tension bars [AMR **7**, Rev. 105] are worked out. By comparison with experiment it is found that the theory is unacceptable, since it predicts very much less thinning in the neck than is observed. Reviewer had already indicated that theory would prove defective in this respect (see last sentence of afore-mentioned review). Author appears to be unaware of, or unpersuaded by, previous work on this subject [R. Hill, *J. Mech. Phys. Solids*, **1**, 19, 1952].

R. Hill, England

657. Wang, A. J., and Prager, W., Thermal and creep effects in work-hardening elastic-plastic solids, *J. aero. Sci.* 21, 5, 343–344, 360, May 1954.

Extremum principles governing the isothermal deformation of a work-hardening elastic-plastic solid have been given by Hodge and Prager [AMR **2**, Rev. 1387] and Hill [AMR **4**, Rev. 2471]. In the present note it is shown how these principles can be extended to include thermal and creep effects.

From authors' summary by W. M. Shepherd, England

658. Mathauser, E. E., Investigation of static strength and creep behavior of an aluminum-alloy multiweb box beam at elevated temperatures, *NACA TN* 3310, 21 pp., Nov. 1954.

Results of an investigation to determine the static strength and creep behavior at elevated temperatures of seven nominally identical multiweb box beams made of 24S-T3 aluminum alloy are presented. The methods that were used to predict failure stresses in the static-strength tests were in good agreement with the experimental results. Creep deflections and creep lifetimes are presented for beams subjected to constant loads and to various heating conditions. Lifetime is satisfactorily predicted from material stress-rupture data when tensile failure occurs at both constant or varying temperatures. From author's summary

659. Gossick, B. R., Design of extensometer for creep studies, *Rev. sci. Instrum.* **25,** 9, 905–909, Sept. 1954.

The extensometer permits remote operation over a wide range of extensions. The creep specimen is mechanically coupled to a metal core within a mutual inductance bridge. The amount of deformation of the creep specimen determines the position of the core and thus the amount of bridge unbalance. The tolerances of mutual induqtance bridges being imperfect, a residual voltage remains which is 90° out of phase with that produced by displacements of the core. A core which produces an output voltage 90° out of phase with the voltage produced by a steel core has been made with laminations of copper and steel. By connecting two bridges in series, one containing a steel core and the other the composite core, the null has been reduced to the noise level of the amplifier to which the bridge system is connected.

Requirements for making the phase angle of the bridge signal approximately independent of core position, over the extension range, are discussed. From author's summary

Failure, Mechanics of Solid State

(See also Revs. 631, 632, 658, 671, 794, 895, 896)

660. **Beck, P. A., Annealing of cold worked metals,** *Advances in Physics* **3, 11, 245–324, July 1954.**

Paper is a comprehensive review of research developments which have taken place in recent years concerning fundamental metallurgical processes which occur during the annealing of cold-worked metals. These processes are divided into (a) recovery, (b) subgrain growth, and (c) recrystallization. Under (a), such topics as recovery of work-hardening, stored energy due to cold work, x-ray line broadening, and recovery of electrical resistivity are treated. Under (b), factors affecting subgrain growth and the mechanism of subgrain formation are discussed. Subjects treated under (c) include energy released during recrystallization, kinetics of grain growth, nucleation, annealing textures. Discussion of the various processes is primarily from the viewpoint of metallurgy and solid-state physics. A comprehensive bibliography of approximately 200 references is given. A. M. Wahl, USA

661. **Argyris, J. H., Flexure-torsion failure of panels,** *Aircr. Engng.* **26, 304, 305; 174–184, 213–219, June, July 1954.**

Paper presents comprehensive discussion of instability of stiffened panels under compressive loads. A detailed analysis is given of the elastic flexure-torsion buckling of stiffeners with a wave length of greater order of magnitude than the stringer height and pitch. Formulas for computing the restraint afforded by the plate to the stringers, and graphs which greatly simplify the computation of geometrical properties are presented. The conditions for symmetrical and antisymmetrical buckling modes are set forth. A number of figures are given showing how to obtain the critical stress in torsion bending from the critical stresses in flexure and in torsion. Two examples demonstrate how the methods are applied. S. Levy, USA

662. **Forrest, G., Internal or residual stresses in wrought aluminium alloys and their structural significance,** *J. roy. aero. Soc.* **58, 520, 261–276, Apr. 1954.**

Author gives in the first part of his paper a complete review on the different types of formation of internal or residual stresses, such as the formation due to quenching and due to various types of plastic deformation. He also discusses the magnitude and the distribution of the internal stresses in certain members of these individual cases and deals with the reduction and control of residual stresses in general. He discusses the advantages and disadvantages of several stress-relieving treatments, such as thermal stress relieving, modified quenching and stretching treatments. In the second part of his paper he describes the practical significance of residual stresses. Whereas the structural behavior under tension is not much affected by internal stresses, the fatigue behavior of structures may change considerably. Other effects, such as the distortion during machining and the stress corrosion, are mentioned. A. W. Cochardt, USA

663. **Heimerl, G. J., Time-temperature parameters and an application to rupture and creep of aluminum alloys,** *NACA TN* **3195, 35 pp., June 1954.**

The application of time-temperature parameters to stress-strain, rupture, and creep data for metals and alloys is reviewed. Some comparisons are made of theoretical and experimental parameters. A parameter based upon rate-process theory was successfully applied to rupture and creep data for aluminum and various aluminum alloys. The value of the constant in the parameter, which provided the best correlation of the data, was determined for each material and application. Master curves of stress against the parameter, which summarize extensive data on the aluminum alloys, are presented for rupture, minimum creep rate, and time to 1% strain. Predictions of long-time life from short-time data are shown to be possible.

From author's summary by E. A. Davis, USA

664. **Kochendörfer, A., Conditions for brittle and ductile fracture based on properties of dislocations. Parts I, II** (in German), *Arch. Eisenhüttenw.* **25, 7/8, 351–372, July/Aug. 1954.**

Part I. "Stability limits of piled-up dislocations leading to microcracks." Mechanisms are described, based on static and dynamic properties of dislocations which lead to brittle or ductile fracture, respectively. Calculations show that certain arrangements of dislocations represent an unstable energy condition and thus lead to microcracks. Nucleation of a microcrack occurs when the energy stored in a group of dislocations equals the surface energy of a microcrack. It is shown that two double dislocations are unstable with respect to a microcrack of nine atomic distances and that the stable length of microcracks increases rapidly with an increasing number of dislocations.

Part II. "Formation and propagation of cracks as a function of temperature, strain rate and state of stress." Possible ways of formation of microcracks and the conditions under which these cracks may lead to brittle or ductile failure are treated. It is shown how a group of dislocations may lead to a microcrack and how this crack can enlarge by the same mechanism until it reaches microscopic dimensions; at this stage Griffith's fracture mechanism is assumed to lead to failure.

Because of the strong repulsive forces between dislocations (of equal sign), crack formation by means of this mechanism presupposes dislocation velocities of more than 9/10 of sound velocity. If these conditions are satisfied, it is shown that a microcrack will lead to fracture without observable plastic deformation, i.e., brittle fracture. Other conditions lead to plastic slip and subsequent ductile fracture. It is described how, in the latter case, vacancy condensation may also lead to formation of microcracks of atomistic dimensions; this crack is further enlarged by dislocations and finally by the Griffith mechanism leading to rupture. It is shown that the path of a crack is generally determined by events during propagation; i.e., beyond the nucleation of microcracks.

A relationship is given for the increase in ductile-to-brittle transition temperature with increasing strain rate and due to (strain) aging.

It is pointed out that, in polycrystalline material, the analysis is complicated by grain boundary stresses which have different effects in various (crystallographic) structures. A more precise evaluation of boundary stresses is a prerequisite for a better understanding of the brittle fracture mechanism in polycrystalline material under multiaxial stress conditions.

F. Forscher, USA

665. **Chilver, A. H., The estimation of fatigue damage in aircraft wing structures,** *J. roy. aero. Soc.* **58, 522, 396–402, June 1954.**

A simple cumulative fatigue damage law is used to estimate the endurance of structural components subjected to alternating wing loads encountered by an aircraft in flight. From recent gust data, the fatigue damage is expressed as a function of gust velocity. The sum of the fatigue damages of different gust velocites gives the life of the structure. The fatigue damage is studied for the range of altitude (1) up to 12,000 ft, and (2) above 30,000 ft.

The fatigue damage depends, to a great extent, on the altitude of flying. It is found from the calculations that the life of the

structure depends almost entirely on the gust velocity which, when applied alone, gives an endurance of about two million cycles. The results of this paper are compared with the work published by other authors. T. H. Lin, USA

666. Kawamoto, M., and Nishioka, K., Fatigue and stress distribution, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 101–106.

With regard to hysteresis loop, authors determine stress distribution in specimen during fatigue tests. As examples they describe bending of diverse cross sections and torsion of tubular specimens. Relation between form factor and notch factor of twisted specimen is given. Calculated results agree with experimental results. H. Mussmann, Germany

667. Cross, R. H., and Norris, G. M., Method of preventing fatigue failure of steel bolts, *Engineer, Lond.* **198,** 5148, 410–411, Sept. 1954.

It is shown that locking two nuts together can prevent fatigue failure of a bolt in tension by effecting a reduction in the alternating load borne by the peak-loaded thread immediately inside the inner face of the inner nut. Fatigue tests on $^3/_8$-in. B.S.F. bolts with two locked nuts show that the magnitude of the internut torque determines whether or not fatigue failure will occur.

From authors' summary

Material Test Techniques

(See also Revs. 659, 676)

668. Keil, A., and Meyer, C.-L., A nondestructive technique for detecting cracks in tungsten by means of eddy currents (in German), *Z. Metallk.* **45,** 4, 194–196, Apr. 1954.

Eddy-current detection of flaws is not new, but the authors feel this particular instrument used has advantages over earlier ones. The instrument (apparently of commercial manufacture by Dr. F. Foerster of Reutling) is not described in any detail, nor is any reference made to published descriptions of it; therefore, discussion of its application is difficult to evaluate. A correlation of its readings on flaws in 2-mm to 8-mm-diam rods is made with enlarged photographs of them in the cross-sectioned rod. There are a description and explanation of the origin of typical flaws which occur in the manufacture of tungsten rods.

G. H. Sines, USA

669. Gyenes, Mrs. M., Testing aluminum alloys by the stress-corrosion method (in Hungarian), *Kohászati Lapok* **5,** 1, 1–10, 13 figs., 9 tabs., 1953.

The testing method elaborated for comparing the corrosion resistance of different aluminum alloys was also found suitable for investigating the effects of heat treatment and that of the impurities present in alloys of identical composition. On the basis of data obtained by experiments conducted with aluminum alloys of different composition in different media and under different stresses, it was possible to select the optimum experimental conditions for further comparative investigations (e.g., to observe the effects of improving additions). These experiments made it possible to collect information for comparing the properties of new alloys. It could be established in connection with the mechanism of stress corrosion that stress can increase the intercrystalline corrosion in certain cases by straining the weakened grain boundaries, thereby causing cracks. However, intercrystalline corrosion cannot be caused in aluminum alloys which are not prone to corrosion without the influence of external stresses.

Courtesy of Hungarian Technical Abstracts D. V.

Mechanical Properties of Specific Materials

(See also Revs. 650, 653, 655, 658, 662, 663, 668, 669, 800, 886)

670. Young, J. F., Materials and processes, 2nd ed., New York, John Wiley & Sons Inc.; London, Chapman & Hall, Ltd., 1954, ix + 1074 pp. $8.50.

This is a text and reference volume which reviews nearly all the important industrial materials and many of the processes which turn them into useful products. In compiling a book on so broad a subject it is sometimes difficult to know when to stop. An expert who writes one chapter (and several of the author's colleagues have contributed here) is tempted to go into too much detail. Mr. Young has done a good job in maintaining balance among the 24 chapters presented, although one might compare the detail devoted to metallic corrosion with omission of the true stress-true strain curves in tensile testing. Excellent and concise reviews are given to the subject of steels and their treatment, as well as to plastics. Most of the chapters give enough references to allow readers to follow up on details when they are needed; review questions also append each chapter. It is especially difficult sometimes to describe complex processes, machining for example, with enough detail for practical use while at the same time staying within publisher's weight limits. However, the book is certain to find acceptance by both students and practicing engineers.

E. G. Loewen, USA

671. Bordoni, P. G., Elastic and anelastic behavior of some metals at very low temperatures, *J. acoust. Soc. Amer.* **26,** 4, 495–502, July 1954.

See AMR **7,** Rev. 808.

672. Schottky, H., On the susceptibility of construction steel to hardening and improvement in quality, and on testing techniques (in German), *ZVDI* **96,** 7, 195–202, Mar. 1954.

Author reviews present methods of hardening and subsequent heat treatment, and the various testing and calculation methods in this field which make possible the prediction of mechanical properties and structure at any place in a quenched and tempered constructional part. Principal methods discussed are the Jominy test on hardenability, the measurement of quench intensity, and the time-temperature-transformation diagram of the steel. J. H. van der Veen, Holland

673. Wylie, R. D., Corey, C. L., and Leyda, W. E., Stress-rupture properties of some chromium-nickel stainless-steel weld deposits, *Trans. ASME* **76,** 7, 1093–1104, Oct. 1954.

674. Marsh, C., Large diameter aluminium tubes in structures, *Engineer, Lond.* **198,** 5153, 584–586, Oct. 1954.

675. Emöd, Gy., Nickel-free malleable high-tensile strength aluminum alloys (in Hungarian), *Kohászati Lapok* **5,** 5, 97–103, 14 figs., 4 tabs., 1953.

With an addition of 1% Cu, the Al-Mg-Si-type alloys can be satisfactorily substituted for the Al-Cu-Mg type since their strength properties are very similar, and moreover their corrosion resistance is far superior. Furthermore, they can be formed just as well as the Al-Mg-Si alloys. The high-strength Al-Mg-Zn-type alloys have proved excellent for forging as well. From the viewpoint of corrosion, these alloys are not inferior to Al-Cu-Mg if adequate inhibitors are added. Among the inhibitors the behavior of Cr, V, and Ca is similar, while Ti lends far better proper-

ties to the alloy. According to H. Hug, the Al-Mg-Zn-type alloy also proved suitable for railway car drawhooks.

From author's summary

Courtesy of Hungarian Technical Abstracts

676. Lucas, G., and Lutsch, A., Determination of the segregation zones in cast aluminum-magnesium-silicone alloy by the ultrasonic reflection method (in German), *Z. Metallk.* **45**, 4, 158–160, Apr. 1954.

During the casting and freezing of some alloys, temperature gradients may lead to extensive segregation zones which are richer in one or more constituents than in adjacent zone. Standard ultrasonic reflection techniques cannot easily distinguish such zones. Paper describes modification in which time display of reflection from far side of workpiece is magnified to show small differences in travel time, correlating with velocity of sound in alloy zones of slightly different composition. V. Salmon, USA

677. Powers, T. C., Void spacing as a basis for producing air-entrained concrete, *J. Amer. Concr. Inst.* **25**, 9, 741–760, May 1954.

Variations in the air content of a concrete mix do not necessarily affect the frost resistance. Author suggests that the design and control of air-entrained concrete be based on the void spacing rather than the percentage of entrained air. Tests on specimens having large variation in mix design and size of voids gave similar values of frost resistance when the void spacing was the same. The void spacing depends upon the paste content and the specific surface of the voids (sq in. per cu in.), which, in turn, is a function of the type and amount of fines in the mix. If the total air content is held the same for all materials, differences in the void spacing will result.

Author suggests designing mixes for a void spacing of 0.01 in. and suggests a method based upon the determination of the void spacing from trial mixes. He suggests keeping air-entraining agent constant for a given job and neglecting normal variations in air content. I. A. Benjamin, USA

678. Whitlam, E. F., Autogenous healing of concrete in compression, *Struct. Engr.* **32**, 9, 235–243, Sept. 1954.

Concrete that has failed in compression (or tension) possesses the property of healing, providing the fractured parts are maintained damp and in intimate contact. The experimental work described in this paper was carried out to ascertain if any quantitative results could be found concerning healing in compression and how it was connected with the general hardening process in concrete. Only one mix of concrete was used and initial tests were made to ascertain the most suitable degree of failure for specimens to be healed. Concrete cylinders 5-in. diam. × 10 in. high were used. A series of these were tested at varying ages and retested after further periods of curing. Load-compression (or deformation) curves were taken for each test. It was found that the healing followed the same form as the general hardening process in concrete, and it is thought probable that the healing is dependent upon the damage sustained by the initial compression test. A possible law for the deformation of concrete up to the point of failure is suggested for ordinary and healed concrete. Finally, practical consideration is given to the healing process in everyday site work. From author's summary

679. Nylander, H., Non-uniform shrinkage of concrete due to segregation of coarse aggregate, *Publ. int. Assn. Bridge struct. Engng., Fourth Congress*, 15 pp., Sept. 1952.

In some tests on vibrated reinforced-concrete beams it was shown that the counteractive effect of the reinforcement on shrinkage was of minor importance in comparison with the effect produced by nonuniformly distributed shrinkage owing to the segregation of the coarse aggregate. Type tests with nonreinforced beams showed the influence of varying consistency and time of vibration on the nonuniform shrinkage.

The magnitude of moments and deformations due to nonuniform shrinkage in slabs supported on four sides was calculated. It was shown that these moments and deformations at an allowable load can be of the same order of magnitude as the moments and stresses caused by the load, primarily in the case of the simply supported slabs, but also in the case of slabs clamped along two opposite edges.

A method of reducing nonuniform shrinkage was examined. An additional layer of coarse aggregate was spread on the surface of the concrete after placing and this layer was subjected to vibration so that the coarse aggregate was mixed with the freshly poured concrete. It was shown that there are possibilities of reducing or eliminating the nonuniform shrinkage by this method.

From author's summary

680. Brown, W. E., and Sosman, R. B., Variables in the load test for fire-clay refractories, *J. Amer. ceram. Soc.* **37**, 11, 552–558, Nov. 1954.

The so-called load test, as applied to refractory fire-clay brick, was studied from two points of view. The present ASTM standard test procedure is found to give results, on specimens smaller than the standard size, that depend on the cross section and length of the specimen. A more informative and more reliable test, constituting the second part of the study, consists in recording the curve of deformation against time at a constant temperature. The deformation of fire-clay brick at 2100 to 2550 F is an exponential function of temperature, and the flow up to 24 hours fits the equation for flow of glass. At constant temperature, between 2100 and 2550 F, the permanent deformation after cooling is proportional to the load for the range 15 to 40 psi.

From authors' summary

681. Beyer, H., Rubber, a construction element for rails (in German), *Dtsch. Eisenbahntech.* **2**, 3, 83–90, Mar. 1954.

Mechanics of Forming and Cutting

(See also Revs. 609, 630, 816, 859, 860, 861)

682. Fast, J. D., Luteijn, A. I., and Overbosch, E., Preparation and casting of metals and alloys under high vacuum, *Philips tech. Rev.* **15**, 4, 114–121, Oct. 1953.

This is an improvement of a laboratory high-frequency induction furnace described in title source, **11**, 241–244, 1950. Melting and refining are combined with casting of an ingot under high vacuum, thereby minimizing the risk of introducing impurities into the pure alloy during processing.

The importance of the crucible material is illustrated by the improvement in the purity of iron when refined in an MgO instead of an Al_2O_3 crucible. In the former case, the individual contents of Mg, Si, Al, Cu, Co, Ni, C, S, and O_2 could be reduced to well below 0.005%.

The method has been developed for metallurgical research. It may, however, gain practical importance; e.g., for producing metals exceptionally free from gases for electron tube components. H. R. Fehling, England

683. Trigger, K. J., Thermal number measures efficiency of metal cutting, *Amer. Machinist* **98**, 12, 145–152, June 1954.

Paper gives an analysis of carefully determined data from

hundreds of turning tests. Observations were made of two components of cutting force and cutting temperature for NE 9445 and SAE 52100 steels. The results show substantial drop in both components of force with increase in speed from 60 fpm up to as much as 600 fpm. Similar trends have been reported by other observers, but few have observed as much reduction. The feeding or longitudinal force is shown to drop 54% as the cutting speed is increased from 100 to 600 fpm. It is possible that some of this apparent reduction is due to the use of inductive transducers with low carrier frequency. The results from both force and temperature measurements are very consistent, indicating careful techniques.

The curves of cutting force vs. speed show steady increase as the speed is reduced to about 60 fpm, after which the measured force decreases abruptly. This is attributed to formation of a substantial built-up edge. However, temperature measurements in the same low-speed range give no such indication. The conclusions regarding the influence of cutting speed, feed, and thermal diffusivity corroborate the effects of these same variables on tool life. The author points out that cutting temperature is more sensitive to cutting speed than to feed. This is consistent with the generally known fact that the rate of metal removal for a fixed tool life is greater for larger feeds in spite of the necessarily lower speeds. L. V. Colwell, USA

684. Cook, N. H., Loewen, E. G., and Shaw, M. C., Machine-tool dynamometers—a current appraisal, *Amer. Machinist* **98, 10, 125–129, May 1954.**

685. Shaw, M. C., Plastic flow in the cutting and grinding of materials, *Proc. nat. Acad. Sci. Wash.* **40, 6, 394–401, June 1954.**

In this interesting and informative discussion of the size effect on the strength of metals, author gives an experimental curve of variation of energy per unit volume of metal cut u as ordinate with depth of layer removed, or particle size t as abscissa. Curve exhibits a flat up to particle sizes associated with grinding, then is an equilateral hyperbola on through milling and turning. Experimentally, the shear strain in a chip is about 3, independent of chip size, and if it is assumed that the friction energy (u_f) is half the total energy u per unit volume, it is then possible to obtain the following estimate of shear stress τ: $\tau = u/6$. Thus shear stress may be obtained directly from particle size. This procedure yields very high shear stresses compared to those usually associated with materials at the same strain, but τ corresponds closely with estimates of the shear stress of a specimen if it were free of lattice imperfections, $G/2\pi$. An interpretation of the curve is that the particle sizes along the flat are so small that the probability of their containing an imperfection is negligible and the flow or shear stress corresponds to the theoretical. When the particle size exceeds that in this region, the probability of finding an imperfection is increased, hence flow stress is decreased.

Numerous examples are discussed wherein significant size effects were found, especially a case of thin silver films in which the tensile strength came within a factor of 4 of the theoretical, $2G/2\pi$. Author explains difference in size-effect concept as applied to tension or to torsion cases in terms of stress gradients. "The thickness of the zone of initial yielding will depend on the steepness of the stress gradient at the surface. The steepness of gradient will be greater for a small specimen, and the layer of initial yielding will be thinner. The yield stress of a small specimen subjected to a stress gradient should therefore be expected to be greater than that for a large specimen, due to the size effect. Tensile specimens fail to reveal a size effect since the stress is uniformly distributed at the yield point, and initial yielding occurs across the entire specimen."

Author then applies same line of reasoning to process of comminution. The Rittinger and the Kick empirical energy (of grinding) relations are rearranged, with reference to size and area, and to size and volume of particle, resulting in expressions: $u_R = k_1/t + u_0$, corresponding to the hyperbolic portion of the above curve; and $u_K = k_2$ for the flat. These expressions thus hold for different ranges of particle sizes. Both rules have been previously shown elsewhere to be based on false concepts and author comments on fact that both rules agree with experiment despite their false basis: "The important lesson is that experimental verification of an end-result does not necessarily constitute a verification of the assumptions and reasoning leading to this result." Author concludes: Materials that are brittle in ordinary size are quite ductile in the size range involved in comminution. It is for this reason that cutting data for metals are so similar to comminution data for normally brittle materials. As in metal cutting, the energy associated with comminution will be divided between the shear and friction processes, and a negligible amount will be involved in formation of new surface area.

C. C. Osgood, USA

686. Letner, H. R., A modern perspective of the grinding process, ASME Fall Meet., Milwaukee, Wis., Sept. 1954. Pap. 54—F-4, 11 pp.

In metalworking, grinding is used advantageously to remove excess stock economically, to improve the appearance of surfaces, to obtain high dimensional accuracy, and to generate surfaces of specified finish. There is evidence that polishing may be a continuation of the process of grinding on an extremely small scale. The author examines these processes from the theoretical as well as the practical aspects. The effect upon the abrasive, upon the chips produced, and upon the work is discussed in some detail.

From author's summary

687. Yang, C. T., and Shaw, M. C., The grinding of titanium alloys, ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-57, 21 pp.

When titanium is ground under conventional conditions the rate of wheel wear is abnormally high and the finish produced is poor. Improvement in surface finish accompanies a decrease in wheel-wear rate. A study of the influence of a wide variety of operating and grinding-wheel variables reveals the most important quantities to be grinding-wheel speed, type of abrasive, and grinding fluid. When a wheel speed of 1500 to 2000 fpm is used with a suitable fluid and a white aluminum-oxide wheel of conventional hardness, grain size, and bonding, greatly improved results are obtained. All of the observations that have been made can be explained in terms of the assumption that bonding between titanium chips and abrasive grains is of major importance. While most of the experiments and discussion are centered around the surface-grinding operation, cylindrical grinding and the cut-off operations are also considered. From authors' summary

688. Swift, H. W., The mechanism of a simple drawing operation, *Engineering* **178, 4627, 431–435, Oct. 1954.**

689. Halmos, Gy., Investigations on the deep drawing of aluminum sheets containing larger amounts of iron and alloyed with manganese (in Hungarian), *Kohászati Lapok* **5, 4, 73–77, 10 figs., tabs., 1953.**

The deformability of aluminum is impaired to an increasing degree by an Fe content exceeding 0.5%. Tests conducted at the Research Institute of the Metal Industry have proved that the harmful effect of iron can be eliminated in case of an Fe content of 0.5 to 1% by alloying with manganese. The deep drawing

ability and strength of sheets containing 0.8 to 0.9% Fe and 0.5 to 0.6% Mn correspond roughly to that of 99.5% aluminum; however, its resistance to corrosion is lower. Surface treatment may be applied whenever necessary. Aluminum containing 0.5 to 1% Fe and alloyed with manganese can be successfully substituted for 99.5% aluminum in less exacting fields where the finished pieces are not subjected to heavy corrosion or where corrosion can be prevented by surface treatment.

From author's summary

Courtesy Hungarian Technical Abstracts

Hydraulics; Cavitation; Transport

(See also Revs. 593, 649, 652, 828)

690. **Bleines, W., Calculation of nonuniform flow in channels with breaks in the cross section** (in German), *Bauingenieur* 29, 9, 339–342, Sept. 1954.

For channels which can be divided into a deep main portion with shallow overbank portion, a procedure is derived for calculating flow profile. Different roughnesses and lengths are allowable for each section. Example is given of computation procedure which shows that different velocities result in each portion. Reviewer believes paper will be of use in backwater and flood-routing computations. W. D. Baines, Canada

691. **Kindsvater, C. E., and Carter, R. W., Tranquil flow through open-channel constrictions,** *Proc. Amer. Soc. civ. Engrs.* 80, Separ. no. 467, 27 pp., Aug. 1954.

It is frequently convenient to determine the discharge of a stream by observing the drop in the water surface at an area constriction. Following a detailed description of the flow pattern in the vicinity of a constriction, authors proceed from the equations of energy and continuity to derive a discharge equation containing an empirical coefficient of discharge C. Factors affecting C are grouped by dimensional analysis and the most significant are evaluated experimentally for a variety of boundary conditions. Results are presented in dimensionless, graphical form and a computation procedure for their use is outlined.

Although results are somewhat approximate due to lack of evaluation of all variables, reviewer finds this a worth-while addition to knowledge of subject. W. DeLapp, USA

692. **Einstein, H. A., and Harder, J. A., Velocity distribution and the boundary layer at channel bends,** *Trans. Amer. geophys. Un.* 35, 1, 114–120, Feb. 1954.

An analysis of the accelerating forces available within a relatively wide shallow channel bend shows that the existence of higher velocities near the outside bank requires, in addition to the helical flow pattern commonly observed, that the outward flowing upper layers be unaffected by bed shear. Velocity measurements made in a model channel bend at a point unaffected by entry conditions have confirmed this requirement, indicating that the inward flowing bottom layers move within a boundary layer similar to those found near the surface of airfoils. The parameter $(r/v)\, dv/dr$, which should have the value -1 for free vortex flow and $+1$ for flow with constant angular velocity, exceeded $+4$ in these experiments and was found to be directly proportional to the friction factor. Theory developed indicates that this parameter is directly proportional to the width-radius ratio also in those regions beyond the effect of entry conditions.

From authors' summary

693. **Sackmann, L. A., Transition regions in canals** (in French), *C. R. Acad. Sci. Paris* 239, 5, 389–391, Aug. 1954.

694. **Khovanskiĭ, G. S., Transparent nomogram for critical depth in trapezoidal channels** (in Russian), *Gidrotekh. Stroit.* 32, 2, p. 48, Feb. 1954.

Scale sliding along a set of curves permits easy reading of critical depth. A nomogram is added on the cover of magazine.

S. Kolupaila, USA

695. **Agroskin, I. I., Design of trapezoidal channels based on the so-called characteristics of cross section** (in Russian), *Gidrotekh. i Melior.* no. 9, 14–32, Sept. 1953.

A dimensionless number, including the depth, the midwidth, and a function of side slope, is introduced and called characteristics of cross section. Computations are highly simplified by four tables of values appended to article. S. Kolupaila, USA

696. **Khovanskiĭ, G. S., Suitable sections of trapezoidal channels for given side slopes** (in Russian), *Gidrotekh. i Melior.* no. 9, 33–35, Sept. 1953.

Tolerance of departure from so-called best hydraulic section is discussed; a formula and nomogram are developed.

S. Kolupaila, USA

697. **Beard, L. R., Estimation of flood probabilities,** *Proc. Amer. Soc. civ. Engrs.* 80, Separ. no. 438, 21 pp., May 1954.

Data of annual maximum mean-daily flows at 159 long-record river-measurement stations are analyzed to determine the characteristics of the frequency distributions and the reliability of probability determinations made therefrom. It is shown that the logarithms of the flows are normally distributed, which fact makes applicable to flood-flow data a wealth of statistical procedures and criteria. An important result of the verification of this fact is the ease with which region-wide correlation analyses can be made, through which precise hydrologic determinations will be possible. From author's summary

698. **Irmay, S., On the hydraulic conductivity of unsaturated soils,** *Trans. Amer. geophys. Un.* 35, 3, 463–467, June 1954.

From Poiseuille's law, author develops formula for specific coefficient of permeability (dimensions, length squared) for laminar saturated flow through soils. Equivalent pore diameter for spherical particles is used, and a coefficient is applied to account for pore shape and tortuosity. Due to re-entrant angles, a portion of pore water is assumed stagnant and accounted for by modification of hydraulic radius and discharge rate in terms of percentage of voids filled with stagnant water.

The same procedure is repeated for unsaturated flow, with the fraction of pore water moving represented by difference between total and stagnant degrees of saturation (viscous drag assumed unaltered). Dimensionless ratio of unsaturated to saturated specific permeabilities is thereby found to vary parabolically with degree of saturation.

Assuming a convenient value for percentage of stagnant water with liquid only flowing and a different value when only gas is flowing, good agreement was obtained with data published by Wycoff and Botset [*Physics* 7, Sept. 1936] for unconsolidated sands.

Principal conclusion, that ratio of unsaturated to saturated specific permeabilities varies parabolically with degree of saturation if substantiated by further tests for a variety of soils and conditions, could provide a basis for more fundamental treatment of unsaturated flow through porous media.

G. A. Leonards, USA

699. **Long, R. R., Some aspects of the flow of stratified fluids, part II,** *Tellus* 6, 2, 97–115, May 1954.

This is an experimental investigation in order to prove theoreti-

cal analysis by author [AMR **7**, Rev. 353]. A glass-wall channel 10 ft long, 5 in. wide, and 20 in. high was filled with two mixtures, differing little in density, as salt water and CCl_4 with a certain ingredient. Model of barrier crossing the channel was drawn by motor at uniform speed along the bottom. Fourteen excellent pictures show different forms of shock waves, resembling hydraulic jumps and surges, as the height of barrier and depths of both liquids were varied. Theory of a two-liquid system is developed as an extension to the nonuniform flow of one liquid. Implications of meteorological character are discussed, such as earth rotation, air compressibility, temperature inversion, which were not taken into account in this investigation. Study is of great value for this specific field and for general hydrodynamics.

S. Kolupaila, USA

700. Ilgaz, C., Study of the wearing of plane surfaces by a sand-laden jet of water, *Wwys. Exp. Sta. Transl.* 53-6, 26 pp., Sept. 1953 (translated from *Houille blanche* **7**, 554–566, 1952, by van Tienhoven, J. C.).

Experimental study of the wearing of metal plates by a siliceous sand-laden jet of water. Description of the installation used, the equipment, and the measuring methods. Results presented: wearing as a function of the sand concentration, the velocity, the jet diameter, and the nature of the plate.

From author's summary

701. Klimentov, A. N., Bernoulli equation for sludge (pulp) flow (in Russian), *Gidrotekh. Stroit.* **23**, 4, 28–32, Apr. 1954.

All members in the equation are expressed in terms of head of imaginary homogeneous liquid having specific weight of sludge discharge. Correction factors are computed for the velocity head, disregarding, however, different velocities across the section.

S. Kolupaila, USA

702. Escande, L., Comparison of first and second approximation formulas for the stability of two surge tanks with venturi tubes (in French), *C. R. Acad. Sci. Paris* **238**, 8, 865–867, Feb. 1954.

703. Sluice outlet portal and spillway flip bucket, Hartwell Dam, Savannah River, Georgia. Hydraulic model investigation, *Wwys. Exp. Sta. tech. Memo.* no. 2-393, Aug. 1954.

704. Astaficheva, T. N., Computation of water levels after a spillway ending with step (in Russian), *Gidrotekh. Stroit.* **23**, 4, 37–40, Apr. 1954.

Experiments established relationships which may aid in computation of height of step assuring permanent surface form with free jump.

S. Kolupaila, USA

705. Hay, A. D., Weir wave suppressor, "Mémoires sur la mécanique des fluides," *Publ. sci. tech. Min. Air, Paris*, 113–118, 1954.

Author gives design of wave suppressor, for use in flumes and towing tanks, which has proved twice as effective as standard 15-degree beach. Device consists of series of suppressed weirs with each successive crest higher than preceding one. Boxes between weirs trap wave water and return it to channel through bottom orifices. Device is compact and simple to design and operate.

D. G. Huber, Canada

Incompressible Flow: Laminar; Viscous

(See also Revs. 728, 735, 762, 769, 805, 811, 812, 815, 819, 828, 854, 873)

706. Eppler, R., Contributions to the theory and application of discontinuous flows (in German), *J. rational Mech. Analysis* **3**, 5, 591–644, Sept. 1954.

Author deals with the theory of flows with free streamlines, in the case of flow past a prescribed curved obstacle with a given wake underpressure, using the theory of conformal transformations. Comparison is made with experimental pressure distributions for flow past a circular cylinder and with experimental flow patterns for flow past a flat plate normal to the stream. See also related work by L. C. Woods [British *Aero. Res. Counc. Pap.* 15666 in process of publication].

J. T. Stuart, England

707. Helander, L., Yen, S. M., and Knee, L. B., Characteristics of downward jets of heated air from a vertical discharge unit heater, *Heating, Piping & Air Conditioning* **26**, 9, 141–152, Sept. 1954.

The down throw, or measurable length of a downward jet of heated air from a vertical discharge unit heater, is correlated with the outlet diameter and a dimensionless buoyancy number by means of an equation containing an empirical dimensionless throw factor which depends on the fan and the type of outlet employed. The buoyancy number is a measure of the ratio of downward momentum forces to upward buoyancy forces. Two additional performance factors are defined which serve as measures of the system's efficiency.

Two fans and the following types of outlets were tested: a shallow diffusor, a deep conical nozzle, and an annular outlet. The deep conical nozzle gave the best performance characteristics. The need for proper matching of fan and outlet is evident, although no quantitative design information can be gained from the limited amount of experimental data collected. The authors rightly stress the need for further research.

A. W. Gessner, Germany

708. Lord, W. T., and Eminton, E., Slender bodies of minimum wave drag, *J. aero. Sci.* **21**, 8, 569–570, Aug. 1954.

709. Andrews, H. J., The measurement of train resistance, *J. Inst. Locomotive Engng.* **44**, 1, 91–166, 1954.

Paper deals with methods developed and results obtained by British Railways when determining resistance of passenger and freight trains at speeds of up to 70 mph. Resistance of eight-car train in still air is given by $R = 2.193 + 0.0401V + 0.001029V^2$ (lb/t) where V is in mph. For British freight units, $R = A + BV + CV^2$ where A varies between 0.6 and 9.64, B between -0.08275 and 0.16297, and C between 0.0091 and 0.00514. Resistance of Bo-Bo electric locomotives varies between 13 and 18 (lb/t) at 10 and 50 mph, respectively. Paper includes numerous graphs, Fig. 42 indicating that B.R. passenger stock has lowest resistance compared with other data available to author.

Reviewer considers that already published data, only partially utilized by author for comparison with own results, shows that B.R. coach resistance values are typical rather than lower than average.

The value of purely rolling resistance of 2.2 (lb/t) is about the lowest yet recorded. The negative values of B derived by author for some vans and wagons suggest perpetual motion, while the wide variation of A values calls for further analysis.

J. L. Koffman, England

710. **Hrubecky, H. F., Experiments in the air-stream atomization phenomena,** *Heat Transf. and Fluid Mech. Inst.*, 263–274; Univ. of Calif., Berkeley, June 30–July 2, 1954.

This paper concerns the results of tests seeking to relate the degree of atomization to water injection position and orientation in a high velocity air stream. Tests seem to indicate that the greatest degree of atomization is obtained when water is injected parallel to the air flow. The smallest "mean diameters" of droplets occur at the highest air velocities.

The author presents his results in tabular rather than graphical form. During the various runs with parallel injection, author relates droplet diameter to air velocity. Unfortunately, the ratio of air volume rate to water volume rate was permitted to vary so that it is not possible to ascertain how much of the drop-size reduction with increasing air velocity is due to increased relative flow rates. C. R. Mischke, USA

711. **Radcliffe, A., The performance of a type of swirl atomizer,** *Inst. Mech. Engrs.*, 10 pp., 1954.

Results are described of a long series of well-planned experiments carried out at the British National Gas Turbine Establishment. Parameters controlling the flow in swirl atomizers are: flow rate, pressure, diameter of orifice, density of fuel, and viscosity of fuel. A relationship has been found, by means of dimensional analysis, between dimensionless groups of the stated parameters, which relationship holds good for a variety of parameters used in the experiments. Effect of varying atomizer shape upon fuel flow and spray cone angle is noted. For a non-spill atomizer spraying kerosene, the Sauter mean diameter is given. It was found that by increasing the spill the drop size decreases. Seven liquids—carbon tetrachloride, gasoline, kerosene, and four mixtures of kerosene and hydraulic oil—were used, having a density range of 0.75 to 1.6 gram per cu cm and a viscosity range of 0.5 to 25 centipoises; the pressure range was 5 to 1000 psi. The final orifices of the atomizers used were: 0.020, 0.030, 0.040, 0.050, and 0.070 inch. On the basis of equations and charts, it is possible to predict the effect on flow of varying the atomizer shape and the mean droplet size.

K. J. De Juhasz, Germany

712. **Stange, K., Size distribution laws in disintegration processes** (in German), *Ing.-Arch.* **21,** 5/6, 368–380, 1953.

Particle size distribution is an important property of solid powders and of liquid sprays. The empirical equations which have been developed usually correlate some size distribution data but are unsuitable for other data. Theoretical or semi-theoretical derivations of these equations could lead to a better choice of a correlating equation for a given case, or, in some cases, to a determination of the particular distribution process involved. This paper gives such a derivation for two simple model processes, operating on a number of initially uniform particles: (1) a p-fold repetition of a simple breakup into two parts; (2) a single breakup into k parts. In both cases, the individual breakup process is assumed to occur statistically. The first process leads to the logarithmic-normal distribution and the second to a distribution which approximates the Rosin-Rammler equation over the usual range of size distribution data.

Reviewer believes paper is an interesting and well-thought-out contribution to the problem, but is not completely novel. Derivations of the log-normal equation have been given by B. Epstein [*Indust. Engng. Chem.* **40,** 2289, 1948], F. Kottler [AMR **4,** Rev. 1878], and R. A. Mugele and H. D. Evans [*Indust. Engng. Chem.* **43,** p. 1317, June 1951]. Kottler has recently extended his work to show how two similar processes of different rates can lead to a complex combination of two log-normal distributions [*J. phys. Chem.* **56,** p. 442, 1952]. Another approach to a generalized Rosin-Rammler equation has been recently given by Weibull [*J. appl. Mech.* **18,** p. 293, Sept. 1951].

R. R. Hughes, USA

713. **Laird, A. D. K., Stability of gas flow in a tube as related to vertical annular gas-liquid flow,** *Trans. ASME* **76,** 7, 1005–1010, Oct. 1954.

See AMR **6,** Rev. 1376.

714. **Barenblatt, G. I., Movement of suspended particles in a turbulent flow** (in Russian), *Prikl. Mat. Mekh.* **17,** 3, 261–274, May/June 1953.

The problem of the suspension of small concentrations of particles in turbulent flow is studied. The method is an important extension of that of Velikanof in which, using Kolmogoroff's theory of an energy balance, the effect of the suspended particles on the mean flow is deduced. In the present paper, the reaction on the energy fluctuations in the flow is studied and, in particular, the case of two-dimensional steady flow is solved.

This method, while being doubtless more rigorous than the diffusion theories of suspension, is not conveniently applicable to practical use. A. Gordon-Foster, England

715. **Drees, J. M., Lucassen, L. R., and Hendal, W. P., Airflow through helicopter rotors in vertical flight,** *Nat. LuchtLab. Amsterdam Rap.* V. 1535, 9 pp., Dec. 1949, published 1954.

In this report an attempt is made to describe the field of flow through a helicopter rotor, in various working conditions in vertical flight. The limitations of the momentum theory are discussed. The spread of the slipstream explains the existence of an air body around the rotor, working in the vortex ring state. By considering the properties of this air body, the working conditions and the rough behavior of helicopters at moderate rates of descent can be understood more clearly.

From authors' summary

Compressible Flow, Gas Dynamics

(See also Revs. 735, 737, 749, 757, 773, 777, 778, 791, 807, 809 840)

716. **Abramovich, G. N., Applied gas dynamics, 2nd ed.** (in Russian), Moscow, Gos. Izd. Tech.-Teor. Lit., 1953, 732 pp., 371 illus. $1.80.

Contents: Gas Dynamic equations for a single streamline (35 pp.); Some information on hydrodynamics (17 pp.); Shock waves (18 pp.); Acceleration of the gas flow (27 pp.); Single state flow (51 pp.); Theory of the boundary layer. Turbulent flow (80 pp.); Pressure losses in nozzles and diffusors. Gas ejectors (pp. 56); Elements of aerofoil and aerofoil grid theory (105 pp.); Elements of compressor and turbine gas dynamics (152 pp.); Reaction force, Reaction propulsion (43 pp.); Tables (24 pp.).

This text was written for the engine faculties of aviation engineering schools, being based on lectures at the Moscow Aviation Institute. The purpose is to present basic gas dynamics of incompressible and compressible flow as applied to the theory of gas turbines and rocket motors. The fundamentals are clearly and, rigorously presented and the general standard is high.

Reviewer found the last four chapters of particular interest. The dynamics of diffusors and constant area ejectors are considered in great detail and here performance of high-speed diffusors for $dp/dx = \text{const}$, $dv/dx = \text{const}$, $\alpha = \text{const}$, $r = \text{const}$, and $d/dx = \{[d(1 - p')/dx] \times [x/(1 - p')]\} = \text{const}$ where $p' = (p - p_1)/(\rho V_1^2/2)$, are considered. Airfoil grid performance

is dealt with on a theoretical basis, with particular reference to flat plate grids. Author refers to work due to Samoilovich and asserts that the problem has been solved theoretically in the USSR for any configuration, but seems to prefer use of electrohydrodynamic analogy. However, as typical results, those due to Howell [*Proc. Instn. mech. Engrs.* no. 12, p. 153, 1945] are quoted at length without stating original source. The work of Weinig is ignored.

Apart from these "political" twists, the author is to be commended on the clarity with which the book is written. It can be recommended to theoretically minded engineers and advanced students. J. L. Koffman, England

717. Lin, C. C., On a perturbation theory based on the method of characteristics, *J. Math. Phys.* **33, 2,** 117–134, July 1954.

Author introduces a system of characteristic parameters α, β and expresses both the coordinates x,y and the desired solution functions $u(x,y)$, $v(x,y)$ in terms of them. For perturbations from a nearly uniform state, the characteristic curves are nearly straight lines in the physical plane, so the transformation between the characteristic plane and the physical plane can be made approximately affine by appropriate choice of parameters.

Present mathematics treatment follows lines suggested by Freidrichs [*Comm. pure appl. Math.* **1,** 211–246, 1948].

If the coordinates (x,y) are calculated to zero approximation, the perturbation theory in the physical plane results. If they are calculated to the first approximation, a solution corresponding to correction of both families of characteristics is obtained, thus extending the Lighthill-Whitham approach [AMR **3,** Rev. 1829 and *Comm. pure appl. Math.* **5,** 301–349, 1949] with correction on only one family of characteristics.

Method is applied to (1) interaction of two simple waves, (2) reflection of a simple wave from a solid boundary, (3) reflection of a simple wave from a free surface, and (4) wave length of a supersonic jet. S. Kirkby, England

718. Miles, J. W., Linearization of the equations of nonsteady flow in a compressible fluid, *J. Math. Phys.* **33, 2,** 135–143, July 1954.

Conditions for linearization of equations governing a series of flow regimes are investigated in detail. They are expressed in the form of relations between orders of smallness of aspect ratio, fineness ratio, reduced frequency, and Mach number. Particular attention is given to nonsteady compressible flow past three-dimensional plane bodies. Maurice Holt, England

719. Kochina, N. N., On an exact particular solution of the unsteady one-dimensional equation of gas motion (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **97,** 3, p. 407, 1954. (English translation by M. D. Friedman, 2 Pine Street, West Concord, Mass.

For unsteady motion of an ideal gas with plane, cylindrical, or spherical symmetry, a particular solution is given as infinite series in inverse powers of time whose coefficients depend on two arbitrary functions. No discussion of the solution is presented. M. D. Van Dyke, USA

720. Hayes, W. D., The method of superposition of planar wave systems, *J. aero. Sci.* **21,** 4, p. 282, Apr., 1954.

Purpose of this note is to show the solution of a linearized supersonic flow problem by means of the method of the superposition of planar wave systems. From author's summary

721. Leslie, D. C. M., and Perry, J. D., Wave drag of wings at supersonic speeds, *Proc. roy. Soc. Lond. (A)* **225,** 1161, 213–225, Aug. 1954.

The "usual" method of calculating the minimum pressure drag of wings with horizontal planes of symmetry involves double integration of sources over the wing area, differentiation to obtain the pressure field, and another double integration to obtain the drag. For a general wing, both the usual method and the authors' method involve quadruple integrals. In the authors' method the first three integrations yield a geometric distribution function. For wings composed of plane facets separated by sharp bending lines, the function can be evaluated directly and the drag determined handily in one integration.

However, it should be noted that, for such wings, the line pressure source method of R. T. Jones [*NACA TN* 1107, 21 pp., Sept. 1946] yields the pressure field directly and also gives the drag in one integration. It thus appears that the authors' method and that of R. T. Jones involve about the same amount of work. J. Nielsen, USA

722. Guderley, G., The flow over a flat plate with a small angle of attack at Mach number 1, *J. aero. Sci.* **21,** 4, 261–274, Apr. 1954.

This is a further nonsymmetrical problem treated by the transonic approximations; the first concerned the wedge [AMR 5, Rev. 3149]. As in the earlier problem, a cavitation region is formed behind the leading edge due to the large supersonic expansion there, and this complicates the boundary in the physical plane. But in the hodograph plane used by the author, the corresponding boundary is at infinity and can be ignored. The stream function and pressure can then be determined analytically in the transonic part of the field. The pressure distribution on both sides of the plate is calculated and can be represented by fairly simple formulas. Maurice Holt, England

723. Pistolesi, E., Comparison of two methods of calculation of lift in supersonic flow (in Italian), *Atti Acad. Naz. Lincei R. C. Sci. Fis. Mat. Nat.* (8) **13,** 5, 205–210, Nov. 1952, *Pubbl. Fac. Ingegn. Pisa* (15) no. 654, 1953

In linearized supersonic flow theory, two methods are used for computing the lift of flat wings. The first method is based on distributions of doublets, the second method uses vortex distributions. Author investigates the conditions for the equivalence of these two methods. In this way the domain of validity of the first method is determined; for, obviously, the first method fails in all the cases where the two methods lead to different results. R. Sauer, Germany

724. Bertram, M. H., Viscous and leading-edge thickness effects on the pressures on the surface of a flat plate in hypersonic flow, *J. aero. Sci.* **21,** 6, 430–431, June 1954.

725. Ribner, H. S., Shock-turbulence interaction and the generation of noise, *NACA TN* 3255, 60 pp., July 1954.

The interaction of a convected field of turbulence with a shock wave has been analyzed to yield the modified turbulence, entropy spottiness, and noise generated downstream of the shock. This analysis generalizes the results of *NACA TN* 2864, which apply to a single spectrum component, to give the shock-interaction effects of a complete turbulence field. The previous report solved the basic gas-dynamic problem, and the present report has added the necessary spectrum analysis.

Formulas for spectra and correlations have been obtained and numerical calculations have been carried out to yield curves of

root-mean-square velocity components, temperature, pressure, and noise in decibels against Mach number for the Mach number range of 1 to ∞; both isotropic and strongly axisymmetric (lateral perturbations/longitudinal perturbations = 36/1) initial turbulence have been treated. It was found that, in either case, initial turbulence with a longitudinal component of 0.1% of stream velocity would yield a noise pressure level of about 120 decibels; the value of lateral component had relatively little effect.

The present results are applicable quantitatively to flow in ducts or channels containing normal shocks; they are presumed to provide a qualitative guide to the generation of noise by the shock structure in a supersonic free jet.

From author's summary by H. G. Lew, USA

726. **Ribner, H. S., Convection of a pattern of vorticity through a shock wave,** *NACA Rep.* 1164, 17 pp., 1954.

Supersedes article reviewed in AMR **6**, Rev. 3134.

Turbulence, Boundary Layer, etc.

(See also Revs. 692, 725, 736, 807, 808, 809, 851)

727. **Donoughe, P. L., and Livingood, J. N. B., Exact solutions of laminar-boundary-layer equations with constant property values for porous wall with variable temperature,** *NACA TN* 3151, 42 pp., Sept. 1954.

Exact solutions of the laminar-boundary-layer equations for wedge-type flow with constant property values are presented for transpiration-cooled surfaces with variable wall temperatures. The difference between wall and stream temperature is assumed proportional to a power of the distance from the leading edge. Solutions are given for a Prandtl number of 0.7 and ranges of pressure-gradient, cooling air-flow, and wall-temperature-gradient parameters. Boundary-layer profiles, dimensionless boundary-layer thicknesses, and heat-transfer coefficients are given in both tabular and graphical form. Corresponding results for constant wall temperature and for impermeable surfaces are included for comparison purposes.

The results indicate that increasing the wall-temperature gradient yields steeper temperature profiles in the boundary layer for a given coolant flow. The steeper temperature profiles produce increased local heat-transfer coefficients. These effects of the wall-temperature gradient were reduced as the coolant flow was increased. Wall-temperature variations resulting in zero boundary-layer temperature gradients at the wall were found to be increased by increased pressure gradient and decreased by increased coolant flow.

From authors' summary by L. M. Grossman, USA

728. **Kelly, H. R., A note on the laminar boundary layer on a circular cylinder in axial incompressible flow,** *J. aero. Sci.* **21**, 9, p. 634, Sept. 1954.

729. **Tani, I., On the approximate solution of the laminar boundary-layer equations,** *J. aero. Sci.* **21**, 7, 487–495, 504, July 1954.

Author modifies the one-parameter method of Walz [AMR **4**, Rev. 1696]. A simple fourth-degree polynomial is used as the velocity profile similar to the original Pohlhausen scheme, but a coefficient related to the wall shearing stress is chosen as the parameter instead of the usual λ. The momentum and energy integrals are used jointly for the solution. Extension to compressible boundary layer over insulated wall is made on the basis of Rott's modification of the Stewartson transformation [AMR **6**, Rev. 2864]. Comparison with several known incompressible and compressible results involving adverse pressure gradient shows generally very good agreement. S. F. Shen, USA

730. **Cohen, C. B., Similar solutions of compressible laminar boundary-layer equations,** *J. aero. Sci.* **21**, 4, 281–282, Apr. 1954.

731. **Ferri, A., and Libby, P. A., Note on an interaction between the boundary layer and the inviscid flow,** *J. aero. Sci.* **21**, 2, p. 130, Feb. 1954.

732. **Lehnert, R., and Hastings, S., Skin effect on base pressure of cone-cylinders,** *J. aero. Sci.* **21**, 4, 286–287, Apr. 1954.

Experiments were recently carried out at the Naval Ordnance Laboratory to determine the spin effect at zero angle of attack on the stability of the laminar boundary layer and on base pressure at supersonic speeds. From authors' summary

733. **Coles, D., Measurements of turbulent friction on a smooth flat plate in supersonic flow,** *J. aero. Sci.* **21**, 7, 433–448, July 1954.

Results of direct measurements of local skin friction are given for Reynolds numbers from 3×10^6 to 9×10^6 at Mach numbers between 2.0 and 4.5, on a flat plate with approximately zero pressure gradient. The leading edge of the plate had an included wedge angle of 15° and its nose radius was less than 0.005 in. The floating element mechanism was similar to that used by Dhawan [*NACA TN* 2567, 1952] but the measurement involved a null technique using the variable reluctance method. Turbulence stimulation was effected with a sand strip, leading-edge fence, and a row of airjets. It was noted that the distribution of static pressure along the plate varied with Reynolds number and transition point and was different from the tunnel empty condition by about 3% of the free-stream static pressure. It is stated that, in the direct measurement of skin friction, random errors are less than 2% and errors due to the force arising from the flow in the clearance gaps are less than 3%.

An attempt has been made to present the measured data for fully developed turbulent flow ($R_\theta > 2000$) in a form independent of the transition position. The method is consistent with that used by the author in incompressible flow [*ZAMP*, July 1953]. The resulting curve of C_f against R_θ for each value of M has been checked by probe measurements and the agreement was better than 5%. Values of $C_f(\mathrm{M})/C_f(0)$ varied from about 0.70 at M = 2.6 to 0.50 at M = 4.5. These measurements at M = 2.6 are not inconsistent with those obtained by other authors from probe measurements. G. M. Lilley, England

734. **Dorrance, W. H., and Dore, F. J., The effect of mass transfer on the compressible turbulent boundary-layer skin friction and heat transfer,** *J. aero. Sci.* **21**, 6, 404–410, June 1954.

This subject is of interest for cooling rocket nozzles and aircraft surfaces by injection of cooled gases through porous surfaces. Theory is an extension of those without mass transfer which have been developed by Prandtl and von Kármán for incompressible and by Van Driest for compressible flow. Constant pressure flow is assumed. Variation of shear stress near the wall due to mass transfer is taken into account. Authors are aware of the general limitations of mixture-length theories, but are satisfied that, in using it in their problem, good results for skin friction and heat transfer will be obtained. Mixture length is, as usual, taken proportional to distance from the wall. In solv-

ing boundary-layer equations, three arbitrary constants are obtained whose numerical values are determined by specializing formulas for incompressible case.

Boundary-layer characteristics are obtained as functions of Mach number, wall temperature ratio, Reynolds number, and injection velocity. Comparison with available experiments in incompressible flow is good, but authors stress need for experiments at supersonic speeds. H. Schuh, Sweden

Aerodynamics of Flight; Wind Forces

(See also Revs. 561, 642, 715, 716, 721, 724, 732, 770, 833, 834)

735. Rogers, A. W., Application of two-dimensional vortex theory to the prediction of flow fields behind wings of wing-body combinations at subsonic and supersonic speeds, *NACA TN* 3227, 91 pp., Sept. 1954.

Satisfactory aerodynamic design of high-speed aircraft requires knowledge of the interference flow field resulting from wing-body-tail interaction. The behavior of the wing vortex wake in the presence of the body directly affects the air stream flowing past the tail surfaces. In particular, for certain relative sizes and positions of wing, body, and tail, the wing-body vortex wake produces large stream angles at the tail surfaces and nonlinear variation with angle of attack of the pitching moment contributed by the tail. Therefore, it is desirable to be able to predict flow fields at the tail location for a given configuration in order to evaluate stability and control requirements.

To study this problem a theoretical investigation is presented of a general method for predicting the flow field behind the wings of plane and cruciform wing and body combinations at transonic or supersonic speeds and slender configurations at subsonic speeds. The wing trailing-vortex wake is represented initially by line vortexes distributed to approximate the spanwise distribution of circulation along the trailing edge of the exposed wing panels. The afterbody is represented by corresponding image vortexes within the body. Two-dimensional line-vortex theory is then used to compute the induced velocities at each vortex, and the resulting displacement of each vortex is determined by means of a numerical stepwise integration procedure. The method is applied to the calculation of the position of the vortex wake and the estimation of downwash at chosen tail locations behind triangular-wing and cylindrical-body combinations at supersonic speeds. The effects of such geometric parameters as aspect ratio, angle of attack and incidence, ratio of body radius to wing semispan, and angle of bank on the vortex wake behind wings of wing-body combinations are studied. The relative importance of wing vortexes, the corresponding image vortexes within the body, and body crossflow in determining the total downwash is assessed at a possible tail location.

Wake shapes calculated by the presented two-dimensional line-vortex theory agree qualitatively, at least, with wakes observed in a supersonic wind tunnel. Calculated vortex paths using this line-vortex method agree well with a known exact crossflow-plane solution. L. Goland, USA

736. Weiberg, J. A., and Dannenberg, R. E., Section characteristics of an NACA 0006 airfoil with area suction near the leading edge, *NACA TN* 3285, 47 pp., Sept. 1954.

737. Hemenover, A. D., and Graham, D. J., Influence of airfoil trailing-edge angle and trailing-edge-thickness variation on the effectiveness of a plain flap at high subsonic Mach numbers, *NACA TN* 3174, 101 pp., June 1954.

The effects of variation of trailing-edge angle and trailing-edge thickness on the lift characteristics of a 10%-chord thick symmetrical NACA airfoil section with a 25%-chord plain flap are appraised from wind-tunnel tests at Mach numbers from 0.3 to 0.9 and Reynolds numbers varying correspondingly from 1 to 2 million. The airfoil trailing-edge angle was varied from approximately 18° to 6°, and the trailing-edge thickness from zero to the thickness at the flap hinge line.

Reduction of the trailing-edge angle decreases, at moderate angles of attack, the loss of flap effectiveness for small deflections ordinarily noted at high subsonic Mach numbers for airfoils of conventional profile. At zero angle of attack, reduction of the trailing-edge angle has no effect on the variation of flap effectiveness with Mach number, but has the favorable result of decreasing the range of flap deflections for which the effectiveness is zero or negative.

An increase of the airfoil trailing-edge thickness results in an increase of flap effectiveness at virtually all Mach numbers. The results indicate further that, at zero angle of attack, an increase of trailing-edge thickness promotes, in general, an increase of lift effectiveness from the low-speed value in the range of Mach numbers for which the effectiveness of a sharp trailing-edge flap decreases sharply. For the particular thickened trailing-edge flaps investigated, however, the variation of effectiveness with Mach number would appear to be undesirably large.

From authors' summary

738. Miles, J. W., On solving subsonic unsteady flow lifting surface problems by separating variables, *J. aero. Sci.* 21, 6, 427–428, June 1954.

739. Blackaby, J. R., and Watson, E. C., An experimental investigation at low speeds of the effects of lip shape on the drag and pressure recovery of a nose inlet in a body of revolution, *NACA TN* 3170, 48 pp., Apr. 1954.

A low-speed investigation, for an angle of attack and angle of yaw of 0°, was made of the effects of inlet lip bluntness and profile on the performance of a ducted body of revolution. A sharp inlet lip profile was tested in addition to five circular-arc profiles having contraction ratios (ratio of area at inlet leading edge to minimum inlet area) of about 1.04, 1.08, 1.16, 1.24, and 1.33, and two lips with elliptical internal profiles and approximately elliptical external profiles having contraction ratios of about 1.08 and 1.18.

From authors' summary

740. Falkner, V. M., A comparison of two methods of calculating wing loading with allowance for compressibility, *Aero. Res. Counc. Lond. Rep. Mem.* no. 2685, Oct. 1949, 53 pp., published 1953.

The first method of this comparison is associated with vortex lattice theory and deals with changes in Mach number by preserving the planform of the wing and using special tables of downwash. The second method uses the solution for Mach number zero on a wing whose lateral dimensions are reduced by a specified factor (Prandtl-Glauert rule). The following wings are analyzed by both methods: (1) Tapered V-wing with 45° sweep and aspect ratio 5.8. (2) Same wing as above but reduced by Prandtl-Glauert rule for $M = 0.8$ to 59° sweep and aspect ratio 3.5. (3) Straight tapered wing, aspect ratio = 5.87. (4) Tapered wing with 28.4° sweep, aspect ratio = 5.89. (5) Delta wing, equilateral with aspect ratio = 2.31.

The aerodynamic loadings for these wings from both methods are in good general agreement at $M = 0.8$. General and reasonable explanations can be given of the variation of load gradient and local aerodynamic center with increasing Mach number.

Although the second method appears to be more accurate on

theoretical grounds, the first method has considerable advantages in ease of calculations and the possibility of extension to more accurate solutions in cases where the Prandtl-Glauert rule fails at high subsonic speeds. An appendix by W. P. Jones presents exact values (linearized theory) of downwash due to a rectangular vortex over a range of high subsonic Mach numbers and an examination of the approximations made in the first method. The results confirm the accuracy of the (approximate) first method at high subsonic Mach numbers. H. P. Liepman, USA

741. van de Vooren, A. I., An approach to lifting surface theory, *Nat. LuchtLab. Amsterdam Rap.* F.129, 14 pp., June 1953.

This paper overcomes some of the restrictions on chordwise pressure distribution of the Multhopp method and the failure of the Weissinger method to yield moment distributions. The method presented extends the Reissner-Weissinger method to tapered and swept wings without restriction (in principle) on the pressure distribution. This is done by transformation of the untapered rectangular wing of the Reissner investigation. Use is also made of the Weissinger method of splitting off the two-dimensional downwash and of integrating over the vortexes by aid of the pivotal points used to determine the downwash. Two-dimensional downwash for the tapered wing is related to an imagined extension of local geometry. Carried over from the two-dimensional theory are the infinite leading edge and zero trailing edge vorticity. Finally, in the words of the author's summary: "By using a series expansion for the chordwise vorticity distribution, a set of integral equations for the coefficients in this expansion is obtained. All chordwise integrations can be performed by aid of pivotal points for which the best positions are derived. A function, given explicitly in the report, must be evaluated in these points." M. G. Scherberg, USA

742. Palme, H. O., Summary of stalling characteristics and maximum lift of wings at low speeds, *SAAB TN* **15,** 21 pp., Apr. 1953.

743. Maezawa, S., and Murata, S., On the accuracy of approximation formulas for the characteristics of a straight line lattice of aerofoils having camber and thickness, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 403–408.

A zero-stagger lattice of airfoils with finite camber and thickness is devised such that the characteristics can be determined exactly. This case can then provide an example for evaluation of the various approximate lattice theories.

H. M. Voss, USA

744. Kamimoto, G., and Hirai, K., On the experimental methods of straight wing lattice, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 397–402.

Cascade measurements usually assume the center airfoil of a finite cascade behaves as an airfoil of an infinite cascade. Paper evaluates effect of boundaries on circulation of all airfoils in a finite cascade with zero stagger. Conclusion is that above assumption is reasonable for cascades of more than three airfoils.

H. M. Voss, USA

745. Yasuhara, M., On the fundamental theory of the flow through straight lattice of airfoils, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 391–396.

A method is presented for the mapping of a two-dimensional lattice of arbitrary airfoils onto a circle, making use of Fourier series development. The pressure distribution is then found, assuming a wake vortex system. The method results in a favorable comparison with the experiments of Prandtl and Betz.

H. M. Voss, USA

746. Dini, G. E., A contribution to the aerodynamics of helicopters equipped with aerodynamical servocontrol, with particular reference to the D'Ascanio type (in Italian), *L'Aerotecnica* **34,** 3, 142–149, June 1954.

The typical feature of the D'Ascanio helicopter, i.e., blades feathering about their longitudinal axis and servo-controlled by a surface placed behind their trailing edge, is considered. Therefore the equation of equilibrium for the rotation about the blade axis is associated with the well-known equations of thrust, torque, and lift moment of the blades about the rotor center. Moreover, these equations are modified by adding correction terms in order to take into consideration the influence of the servocontrol surface. The method of calculating the value of the cyclical variation of the servocontrol incidence as function of the flight speed of the helicopter and the geometrical and physical parameters of the blades is indicated. Finally, the results of an example of calculation are given. From author's summary

747. Stepniewski, W. Z., On down flapping of a stalled helicopter blade, *J. aero. Sci.* **21,** 6, 428–429, June 1954.

This note is intended to indicate the possibility of an excessive down-flapping motion which may be developed by a stalled helicopter blade. From author's summary

748. Ashley, H., Voss, H. M., and Zartarian, G., The dynamic analysis of low-aspect-ratio airplane wings, *Proc. nat. Acad. Sci. Wash.* **40,** 6, 388–394, June 1954.

Paper reviews briefly results—concentrated on flutter—of some investigations on dynamics of wings which do not conform to the simplified classical picture. A multitude of dynamic aeroelastic problems arise in connection with low-aspect-ratio wings. Troubles appear in Rayleigh-Ritz predictions of flutter speed, and aerodynamic loading is quite sensitive to small changes in slope of its surface in chordwise direction.

Authors believe that their theory, described in preliminary stage, allows use of most accurate practicable aerodynamic theory, independently of changes in planform, and replaces Rayleigh-Ritz procedure by a more systematic and accurate method.

F. Keune, Sweden

749. Martin, J. C., and Gerber, N., The effect of thickness on pitching airfoils at supersonic speeds, *J. Math. Phys.* **33,** 1 46–56, Apr. 1954.

Authors apply their method [AMR **7,** Rev. 1206] to airfoils of arbitrary symmetrical cross section flying in a circular path. The lift due to pitching C_{L_q} and moment due to pitching C_{m_q} are computed, and the results compared with linear theory for a 5% thick parabolic airfoil. No experimental check is given.

R. E. Street, USA

750. Campion, B. S., Estimation of the effects of distortion on the longitudinal stability of swept wing aircraft at high speeds (sub-critical Mach numbers), *Coll. Aero. Cranfield Rep.* no. 77, 46 pp., 11 figs., Jan. 1954.

The effects of distortion on the longitudinal stability of swept-wing aircraft at high speeds (subcritical Mach numbers) are considered on a quasi-static basis. The method employed is based on the theory of Gates and Lyon but involves some extension of this theory.

The treatment of wing distortion is considered in some detail

and the effects of built-in twist and camber and wing weight are included, using the so-called superposition method. The application of the analysis of Lyon and Ripley for investigating fuselage, tail, and control circuit distortion is suggested, but means of modifying and simplifying this procedure where desirable are put forward.

The analysis is illustrated by means of a simple example of a swept-wing fighter aircraft for which wing, fuselage, and tail distortion effects are considered, and the results are discussed with reference to the individual and combined distortion effects, as well as the effect of compressibility.

From author's summary

751. Etkin, B., and Collette, J. G. R., Vertical-tail loads in the rolling pull-out manoeuvre, *Inst. Aerophys. Univ. Toronto, UTIA Rep.* 28, 34 pp., Jan. 1954.

A theoretical analysis is presented of an airplane maneuver representing the transition from a steady, truly banked turn in one direction to a similar turn in the other direction, the angle of attack, load factor, and essential features of the motion being fixed. Two cases—zero sideslip angles, large rudder angles, and vice versa—are dealt with. Typical results are given and compared with those obtained from other methods.

H. Lomax, USA

752. Riley, D. R., Effect of horizontal-tail span and vertical location on the aerodynamic characteristics of an unswept tail assembly in sideslip, *NACA Rep.* 1171, 20 pp., 1954.

Supersedes article reviewed in AMR **6**, Rev. 2872.

753. Schade, R. O., and Hassell, J. L., Jr., The effects on dynamic lateral stability and control of large artificial variations in the rotary stability derivatives, *NACA Rep.* 1151, 24 pp., 1953.

Supersedes article reviewed in AMR **5**, Rev. 2690.

754. Chang, T., General equations of motion of a rigid missile, *Cornell aero. Lab. Rep.* CAL-43, 14 pp., July 1952.

Using vector notation and the concept of momentum transfer, the six general equations of motion are derived. Forces and moments from the jet, jet vanes, and aerodynamic coefficients are included. Some reasonable simplifications are presented.

A. A. Schy, USA

755. Press, H., and Mazelsky, B., A study of the application of power-spectral methods of generalized harmonic analysis to gust loads on airplanes, *NACA Rep.* 1172, 17 pp., 1954.

Supersedes article reviewed in AMR **6**, Rev. 2876.

Aeroelasticity (Flutter, Divergence, etc.)

(See also Rev. 645)

756. Pepping, R. A., A theoretical investigation of the oscillating control surface frequency response technique of flight flutter testing, *J. aero. Sci.* **21**, 8, 533–542, Aug. 1954.

Method for determining flutter stability by means of flight tests is presented. Control surface is excited harmonically and the system stability is determined by the frequency response technique; interpretation of the data is accomplished by a graphical method similar to the well-known Nyquist method. Procedure allows for artificial stability to be introduced into the system for safety during testing without interfering with interpretation of the normal system stability; several types of safety devices are discussed. Typical test results and stability plots are shown and also discussed.

H. N. Abramson, USA

757. Hedgepeth, J. M., Budiansky, B., and Leonard, R. W., Analysis of flutter in compressible flow of a panel on many supports, *J. aero. Sci.* **21**, 7, 475–486, July 1954.

Two-dimensional linearized compressible-flow theory is used, together with elementary beam theory, to analyze the dynamic stability of an infinitely long panel on equally spaced supports, having an air stream of arbitrary speed on one side and dead air on the other. It is assumed that the flutter mode has a spatial periodicity of two bays. Londituginal stresses in the panel are taken into account.

An exact solution for the condition of neutral stability yields two independent equations in the form of rapidly converging infinite series. The results of some numerical calculations made on the basis of the first few terms of one of the series are shown, and states of stability and instability on either side of a flutter boundary are carefully distinguished. The implications of the numerical results are discussed.

From authors' summary by W. P. Jones, England

758. Parry, J. F. W., and Pearson, H., Cascade blade flutter and wake excitation, *J. roy. aero. Soc.* **58**, 523, 505–508, July 1954.

Authors present a new method of plotting the aerodynamic derivatives of a cascaded turbine or compressor blade vibrating in the first bending mode. Simple expressions of the increments of relative velocity δV_1 and angle of attack of relative velocity $\delta\alpha_1$ are derived as functions of blade displacement velocity $\dot{x}$, the upstream wake component V_W and the relevant angles of the blade geometry. Hence the lift increment $\delta F = F\,\alpha_1 \cdot \delta\alpha_1 + F_{v1} \cdot \delta V_1$ is found, the vibrational energy gained may be formed, and the condition of *self-excitation* for zero wake disturbance, and *amplitude* for a given wake disturbance, respectively, is expressed by plotting the blade lift force F, derived from cascade data, as a contour map in a polar coordinate system with relative steam velocity V_1 as radius vector, and the difference of angle of attack α_1, and stagger angle θ, $(\alpha_1 - \theta)$, as argument.

In this contour map it is shown that the condition of self-excitation is equivalent to a negative slope (downhill) of the left function in the y-direction (considering the polar system superimposed on the usual Cartesian x-y system). The amplitude of a wake-excited blade is proportional to the ratio of the slope in a direction $(\alpha_0 + \theta)$ to the slope in the y-direction ($\alpha_0 + \theta$ corresponds to a direction given by the absolute gas inlet angle α_0 and stagger θ).

The stall flutter region is easily indicated by this way of plotting, and earlier difficulties encountered by authors (numerical values then derived proportional to difference between two values of equal magnitudes) are avoided.

The method appears to be of considerable practical interest. Since work on this subject, mostly in USA, now seems to indicate the increasing importance of stall propagation in annular cascades (Emmons, et al., Rannie and Iura, Huppert and Benser, Sears, Marble, MIT-Gas Turbine Lab. Group), it would be interesting to see the above method applied with respect to actual stall conditions of annular compressor cascades.

One of the authors, Mr. H. Pearson, associated with Rolls-Royce Ltd. of Great Britain, has already discussed this and other aspects of vibrating compressor blades in his original paper reporting on research work of the company and entitled "The aerodynamics of compressor blade vibration," given at the Fourth Anglo-American Aeronautical Conference, 1953.

J. R. Schnittger, Sweden

759. Schultze, E., On the excitation of pure natural modes, *J. aero. Sci.* **21**, 8, 566–567, Aug. 1954.

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 715, 716, 747, 754, 782, 783, 784, 791, 792, 824, 841, 842, 866, 892)

760. Bidard, R., Jet propulsion of airplanes. Turbines and axial compressors [Thermopropulsion des avions. Turbines et compresseurs axiaux], 2nd ed., Paris, Gauthier-Villars, 1954, ix + 338 pp. 3900 Fr.

This review of established jet propulsion principles with detailed concentration on the turbojet places decided emphasis on rotating machinery. Author makes extensive use of thermodynamic and aerodynamic approach. Many data of a practical nature are presented. Discussions could be shortened. Book is good reference work in turbomachinery.

R. B. Morrison, USA

761. Todd, K. W., An experimental study of three-dimensional high-speed air conditions in a cascade of axial-flow compressor blades, *Aero. Res. Counc. Lond. Rep. Mem.* no. 2792, 34 pp., 3 plates, Oct. 1949; published 1954.

Tests carried out in a high-speed tunnel on two cascades over the whole speed range up to inlet velocities above the critical velocity gave the following results: Profiles with sharp leading edges, maximum thickness at 50% of the chord and not higher than 10% of the chord result in considerably lower losses at velocities near the critical range and in higher critical velocities. Two- and three-dimensional losses are approximately equal in the low- and high-speed ranges, secondary loss effects being noticeable only in the high efficiency range between low and high speed.

Description of test equipment and detailed charts of results and calculation of performance characteristics are given.

E. Haenni, Switzerland

762. Brzozowski, W., The problem of flow through an axial compressor (in Polish), *Arch. Bud. maszyn* **1**, 2, 187–244, 1954.

First part of paper is a theoretical analysis of flow in axial compressors. Approximate solution is given, neglecting radial component of velocity of the flow [see *NACA TN* no. 1795, 1949]. A numerical example follows.

Second part consists of a theoretical calculation of blade shape, using the single-vortex method and an experimental verification in a blade cascade. Agreement between theory and experiment for a diffusing cascade is rather poor, due mainly (the author thinks) to separation of flow on the blade surface. A low-velocity cascade wind tunnel is used for the experiments. Some further experimental verification at higher velocities would be desirable.

O. Delatycki, Australia

763. Gertsberg, E. Ya., A contribution to the calculation of solid forged turborotors (in Russian), *Inzhener. Sbornik. Akad. Nauk SSSR* **15**, 3–14, 1953.

Paper describes a method for calculating the stresses at the central bore of a turbine rotor made up of a hollow central drum on the outside of which is machined a number of separate disks which carry the blades. The drum is externally stressed by a series of radial loads at the junction of the disks and drum, these radial loads being assumed constant over the area of the junction. The circumferential stresses at the bore are calculated for each disk loading by the Lamé equations and modified by a factor which takes into account the fact that the radial stresses are exerted only over a finite length of the drum. The total stress is the sum of the stresses due to each disk loading and the rotation of the drum.

Axial stresses are not considered. Reviewer believes the results may not produce the critical stresses when the bore of the drum is almost as large as its outside diameter, as is the case with modern drum-type gas turbine rotors.

N. L. Svensson, Australia

764. Chen, Y. N., Scavenging by pressure waves in 2-stroke engines (in German), *Mitt. Inst. Thermodyn. Verbrenn.* no. 12, 93 pp., 1953; prom. no. 2156, ETH, Zürich.

The first part of this thesis is a theoretical study of wave motion in pipes. By means of characteristics [de Haller, *Sulzer Rev.*, 1945], the behavior of compression and expansion waves in air ($\gamma = 1.40$) as well as in exhaust gas ($\gamma = 1.32$) is pictured on several graphs.

The second part contains test results on a single-cylinder Sulzer engine (110-mm bore) showing the improvements in performance by suitable dimensions of inlet engine exhaust pipe diameter and length. Based on a set of CRO diagrams, the calculated and measured pressures vs. crank angle are shown to follow the same general pattern within reasonable accuracy.

This thesis offers a good comparison with the work of Wallace and Nassif ["Air flow in a naturally aspirated 2-stroke engine," Instn. mech. Engrs., London, 1954]. The latter study the same problem by the theory of waves of finite amplitude, thus avoiding the simultaneous construction of position and state diagrams necessary to the method of characteristics.

M. Rand, Canada

765. Groth, K., Simplified measurement of the altitude behavior of unsupercharged four-stroke-cycle diesel engines (in German), *Motortech. Z.* **14**, 12, 349–350, Dec. 1953.

Generalized equations and graphs are presented by which the performance of the engine at altitudes to 3500 m may be determined without the use of elaborate and expensive test facilities to control exhaust back pressure and temperature.

The performance characteristics of a two-cylinder four-stroke-cycle diesel engine with a displacement of 3.3 liters operating at 1300 rpm with fixed air/fuel ratio are presented. The deviation between the calculated and experimental values of BMEP as a function of altitude is shown graphically and indicates that, at an altitude of 3500 m, the BMEP is 11% low if back pressure is neglected.

Volumetric efficiencies were determined from light-spring diagrams of the scavenging loop and compared with calculated values considering the influence of cylinder wall temperature. The results are plotted with BMEP and specific fuel consumption as a function of back pressure.

The results indicate that accurate altitude measurements are possible with conventional laboratory equipment.

C. J. Vogt, USA

Flow and Flight Test Techniques

(See also Revs. 604, 684, 756, 761, 808, 809, 810, 880)

766. Barna, J., Marschalkó rotation viscometer for testing viscosity and structural viscosity (in German), *Acta Techn. Hung. Budapest* **8**, 3/4, 361–367, 1954.

Description of a rotation viscometer in which the torque exerted by the medium to be investigated is balanced by the lever of a sensitive scale. A novel suitable design of the instrument renders it fit for the measurement of the viscosity of colloidal solutions, suspensions, and, of course, dispersions; moreover, the ease with which the speed of its rotation can be controlled makes possible the investigation of structural viscosity as well.

From author's English summary

767. Maier, K. W., New instrument for rapid evaluation of time-displacement curves, *Rev. sci. Instrum.* **25,** 3, 207–212, Mar. 1954.

An instrument is described which makes possible universal evaluation of time-displacement records with regard to velocity and kinetic energy, acceleration and accelerating force, time, and displacement. It consists of a measuring device for reading distances, angles, and second derivatives, and a slide rule for direct conversion of the measured values into the desired values. The instrument can be attached to a standard drafting machine of a drawing board. It has many advantages over the present methods of evaluation; no lines need to be drawn on the record, and the instrument permits much more rapid evaluation with fewer errors and can be used by less highly trained personnel.

From author's summary

768. Waddell, J. H., and Waddell, Jennie W., Photographic motion analysis, *Indust. Lab.* **5,** 9, 67–74, Sept. 1954.

769. Dombrowski, N., and Fraser, R. P., A photographic investigation into the disintegration of liquid sheets, *Phil. Trans. roy. Soc. Lond.* (*A*) **247,** 924, 101–130, 12 plates, Sept. 1954.

A thoroughgoing basic experimental investigation of the disintegration of liquid sheets into filaments, then into droplets, carried out at the British Imperial College of Science and Technology. The energy needed for the production of liquid sheets can be imparted by pressure, by centrifugal force, and by a gas stream (two-fluid sprays). The spraying apparatus is described, and also the refined photographic technique. Types of single-hole fan-spray nozzles are described. The thickness of the liquid sheet is measured. Liquid sheets were produced with a soluble oil-water emulsion, and with liquids of various surface tensions, viscosities, and densities. Factors influencing the stability of liquid sheets are the flow through the orifice, suspensions in the liquid, the flow through the atmosphere, and the surface tension, viscosity, and density of the liquid. Filaments are formed at the edges of a stable sheet, and also during the disruption of the sheet.

The excellent photographs give an insight into the mechanism of liquid sheet formation, the wave motion superimposed on the flow motion of the sheet, and the subsequent disintegration of the sheet into filaments, either at the edges of the stable sheet or almost explosively by tearing apart of the sheet. Liquids with wide range of properties have been used, among them mercury and mercury-sodium amalgam. K. J. DeJuhasz, Germany

770. Saks, N. A., Fundamentals of experimental aerodynamics [Osnovi eksperimentalnoi aerodynamiki], Moscow, Gos. Izdat, Oboron, Prom., 1953, 371 pp., 422 figs. $1.

Text, which is based on author's lectures, deals with aerodynamic similitude, methods of aerodynamic investigations, determinations of velocity and pressures, boundary layer and turbulence, the influence of geometrical parameters and Reynolds number on aerodynamic characteristics of airfoil profiles and wings, maximum lift values, the effect of compressibility upon aerodynamic characteristics, wings of high-speed aircraft, air resistance, aircraft performance characteristics, aerodynamic stability, and aircraft control problems.

The book is biased toward high-speed aerodynamics, the relevant discussions being backed by extensive experimental data due mainly to S. A. Hristianovich. The author considers that the results obtained according to Prandtl's rule are not sufficiently accurate and recommends the use of a correction factor K (due to Hristianovich), i.e., $C_L' = C_L(1/(1 - M^2)^{1/2})\ K$ and $m' = m(1/(1 - M^2)^{1/2})\ K^2$ where approximately $K^2 = 1.02$, 1.06, and 1.14 at $M = 0.4$, 0.6, 0.7, the value of K increasing with increasing C_L values. For $M < 0.8$, $K = 1 + 0.05\ M^2/M^2_{cr}$ approximately. Similarly, the local value of M_{cr} is determined according to $M_{cr} = f(p_{min})$ graphs due to Hristianovich. The text is clear and lucid and its study facilitated by numerous graphs and illustrations.

The introductory chapter on the contribution of Russian scientists to the subject is less factual. According to author, development of experimental aerodynamics is mainly due to Joukowsky, Chaplígin, and their school, but "It is sufficient to mention names of scientists like L. M. Lomonosov, L. Euler, D. Bernoulli, and D. I. Mendeleev to prove that Russian scientists dealt with theoretical aerodynamics long before world's first airplane built by Russian officer A. F. Moshaiski flew in the eighteenth century." Since Euler and Bernoulli were at the Petersburg Academy for seven and eight years, respectively, this raises the question of time required for a visiting scientist to become a native.

Apart from these comments, the book is a good introduction to the subject and of interest as far as some Russian research results are concerned. J. L. Koffman, England

771. Holder, D. W., The high-speed laboratory of the aerodynamics division, N.P.L. parts I, II, III, *Aero. Res. Counc. Lond. Rep. Mem.* 2560, 277 pp., Dec. 1946; published in 1954.

A full account of the early British experimental work on compressible flow, which was conducted in the High Speed Laboratory of the National Physical Laboratory up to the end of World War II is given.

All N.P.L. high-speed tunnels (20 × 8 in., 12 in. diam and smaller) were driven by compressed air injectors located downstream of the working section. The tunnels operated at atmospheric stagnation conditions (using undried air) and Mach numbers up to 1.55. Useful design data on injectors and diffusers for high-speed tunnels are given.

A large variety of experimental techniques are described, including pressure and force measurements, optical methods of flow observation, boundary-layer transition indication and control, surface temperature measurements, etc. Since 1945 some of them have become standard (e.g., internal model strain-gage balances), while other ones, such as determination of profile drag at high speeds by pitot-static traverse of the wake, are no longer in general use.

Most of the experimental work concerned tests of airfoils ranging in thickness/chord ratio from 6% to 20% at Reynolds numbers from one half million to two million. In view of the effects of moisture condensation and tunnel interference, the results of these early experiments should in many cases be regarded as qualitative rather than quantitative. J. Lukasiewicz, Canada

772. Hunczak, H. R., and Rousso, M. D., Starting and operating limits of two supersonic wind tunnels utilizing auxiliary air injection downstream of the test section, *NACA TN* 3262, 28 pp., Sept. 1954.

The starting and operating pressure ratios were determined for two supersonic wind tunnels which employed air injectors to supplement the primary pumping systems of the tunnels. Data are presented for tunnels operating at Mach numbers 3.85, 3.05, and 2.87 over a range of injector-to-tunnel mass-flow ratios of 0.5 to 1.35. At Mach number 3.85, the starting pressure ratio of 9.8 with injectors but with a fixed second throat was reduced to 4.68 with injectors operating at an injector-to-tunnel mass-flow ratio of 1.27. The running pressure ratio was lowered from 8.3 to 4.5. Corresponding reductions at Mach number 3.05 were from 4.5 to 2.71 for starting and from 4.5 to 2.37 for running at a mass-flow ratio of 0.9. Those at Mach number 2.87 were from 3.8 to 2.43 for starting and from 3.8 to 2.13 for running at a

mass-flow ratio of 1.35. The data indicate that the tunnels with injectors operated at pressure ratios approximately 20% greater than the theoretically predicted values.

From authors' summary

773. Pope, A., Wind-tunnel model position for transonic testing, *J. aero. Sci.* **21,** 4, 280–281, 1954.

774. Pope, A., Streamline curvature effects for finite wings in wind tunnels, *J. aero. Sci.* **21,** 4, 279–280, Apr. 1954.

A method of applying the Lotz τ correction to wings is outlined, suitable for the case of finite span wings in wind tunnels.

From author's summary

775. Anderson, J. R., A note on the use of strain gauges in wind tunnel balances, *AGARD Mem.* AG10/M6, 7 pp., 12 figs., Sept. 1953.

776. Diprose, K. V., A scheme of automatic data reduction for wind tunnels, *AGARD Mem.* AG9/M5, 17 pp., Sept. 1953.

777. Lawrence, T., and Kell, C., Zero lift drag measurements on swept wings at transonic and supersonic speeds using the ground-launched rocket-boosted model technique, *Aero. Res. Counc. Lond. curr. Pap.* 145, 34 pp., May 1952, published 1954.

This is mainly a documentary record of drag measurements on 14 swept wings varying in planform from deltas to swept untapered wings, and from 4% to 10% thick. The Reynolds number of the tests was 7×10^6 per foot chord at $M = 1.0$. The results are compared with theory for wings of double wedge section, and an attempt is made to check the validity of the supersonic similarity laws. Three preliminary conclusions are drawn: (a) At supersonic speeds, the wave drag of a given wing varies as the square of the thickness ratio; (b) the supersonic similarity law allows the drag of "similar" wings to be compared; and (c) there is some hope that the drag of round-nose section wings can be estimated from theoretical calculations of the drag of wings of double wedge section. From authors' summary

778. Zienkiewicz, H. K., Chinneck, A., Berry, C. J., and Peggs, P. J., Experiments at $M = 1.8$ on bodies of revolution having ogival heads, *Aero. Res. Counc. Lond. curr. Pap.* 148, 11 pp., Jan. 1953, published 1954.

779. Smith, K. W., The measurement of position error at high speeds and altitude by means of a trailing static head, *Aero. Res. Counc. Lond. curr. Pap.* 160, 34 pp., June 1952, published 1954.

780. Scherer, M., Contribution to experimental wind-tunnel studies of nonsteady motion (in French), *ONERA Publ.* no. 61, 155 pp., 1953.

Report deals with the experimental determination and correlation with theory of the aerodynamic forces and moments on an oscillating body in a low-speed incompressible air stream. The experimental work was conducted at the Alger Laboratory of ONERA in their 1.8 × 2.2-meter rectangular wind tunnel. Three types of models were studied experimentally: (a) a two-dimensional Joukowsky airfoil of 14% thickness; (b) a rectangular planform wing with a span of 1.4 meters, a chord of 0.26 meters, and employing a symmetrical biconvex NACA airfoil section of 8% thickness; and (c) a bimotor aircraft. The studies on the first model were conducted in three phases having as their respective purposes the determination of (1) the critical flutter speed, (2) the lift of the plane airfoil in harmonic oscillation, and (3) the magnitude, position, and phase of the resultant aerodynamic forces and moments as a function of airfoil incidence while oscillating harmonically. The studies on the rectangular planform wing and on the aircraft model were conducted to determine the lateral aerodynamic characteristics of these models; the mounting permitted the model six degrees of freedom and, by making use of the linearized equations of motion, subjecting the model to harmonic oscillations, and analyzing the model displacements, the desired aerodynamic coefficients were deduced.

Using the two-dimensional airfoil section, mounted elastically with two degrees of freedom, and making correction for mount play, the experimental reduced frequencies and critical flutter speeds were in excellent agreement with the values predicted by Theodorsen's theory [*NACA Rep.* 496]. The lift forces on the airfoil section as a function of incidence were measured in the speed range of 20 to 50 meters per second and at frequencies of 10, 15, and 19 cps (corresponding to reduced frequencies of from 0.3 to 1.25); amplitude of oscillation varied between $^1/_2$ and $1^1/_2$ deg.

This work was considered as repeating the work of Reid and Vincenti [*J. aero. Sci.*, Nov. 1940] as well as extending the speed and frequency range investigated; contrary to the findings of Reid and Vincenti, the author found that the form of the experimental curves as functions of reduced frequency was as predicted by theory. The aerodynamic forces and moments were determined on the harmonically oscillating airfoil over a speed range from 20 to 60 meters per second and a range of frequencies from 7 to 15 cps (corresponding to a range of reduced frequencies of from 0.18 to 1.2) with the amplitude of oscillation varying between 1° and 2°. The author estimates accuracy of force measurements to be within 11% (after correcting for play in the mounting) and of reduced frequencies to be 2%. The experimental results on phase measurements gave values below those predicted by theory, and were in agreement with the findings of Reid and Vincenti.

The rectangular wing tested had a center of rotation at the 25% chord point aft of the leading edge. The damping-in-roll coefficients of the wing c_{l_p} was determined experimentally and the values obtained found to be in excellent agreement with those obtained by Lachlan and Letko [*NACA TN* 1309].

The damping-in-roll, damping-in-yaw, and moment-due-to-sideslip derivatives were determined experimentally for the aircraft model, but no comparison with theory or other results is made. Some difficulty was experienced in this phase of the work due to the fact that in some cases air-stream perturbations were of same order of magnitude as movement of the model.

The author gives extensive description of the experimental apparatus and a critical discussion of its limitations, with suggestions for improvement.

Reviewer believes this work to be of much interest both from the viewpoint of aerodynamics and wind-tunnel instrumentation. The studies on determination of lateral stability derivatives were the first performed at the laboratory and are somewhat incomplete; more complete results will form an interesting sequel, especially if the work is extended to determination of the dynamic pitching and plunging characteristics.

The report is lengthy and, while comprehensive, could be shortened in some places without affecting its meaning; reviewer would suggest improvement in report form by (1) addition of a summary at the beginning containing the main results of the work; (2) grouping together all acknowledgments in one section rather than frequent interspersion of rather lengthy acknowledgments throughout the text. G. V. Bull, Canada

781. Raney, D. J., and Beastall, D., Criteria for condensation free flow in the R.A.E. no. 18 (9-in. × 9-in.) supersonic tunnel, *Aero. Res. Counc. Lond. curr. Pap.* 164, 18 pp., June 1953, published 1954.

Tests have been made in the R.A.E. no. 18 (9 × 9 in.) supersonic tunnel to determine the dryness of the air circulating through the tunnel necessary to insure condensation free flow through the working section.

A single test indicates that a strong shock wave has little effect in causing premature condensation but that local expansions around a model may substantially reduce the critical humidity.

From authors' summary

782. Drees, J. M., and Hendal, W. P., The field of flow through a helicopter rotor obtained from wind-tunnel smoke tests, *Nat. LuchtLab. Amsterdam Rap. A.* 1205, 6 pp., Feb. 1950.

In this report results are given of wind-tunnel smoke tests carried out on a simplified helicopter rotor in the open-jet wind tunnel of the N.L.L. For these tests a new method of smoke generation was developed. From authors' summary

783. Strom, G. H., and Halitsky, J., Important consideration in the use of the wind tunnel for pollution studies of power plants, ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-41, 13 pp.

The theoretical bases for wind-tunnel experiments on stack-gas pollution by power plants are examined and important variables and scale factors are set forth. Test results are presented to show some effects of these variables. The test procedure now in use at the New York University $3^1/_2$- by 7-ft wind tunnel is described. Correlation with limited field data is presented with a discussion on accuracy of wind-tunnel experiments.

From authors' summary

Thermodynamics

(See also Revs. 599, 707, 760, 796, 800, 803, 815, 826, 834, 861, 876)

784. Kiefer, P. J., Kinney, G. F., and Stuart, M. C., Principles of engineering thermodynamics, 2nd ed., New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1954, xv + 539 pp. $7.75.

This is an excellent textbook, now rewritten and appearing in a second edition, which the authors enlarged to include also a physical chemist, Dr. Kinney. It will be useful for the student and designer of power machinery, covering steam and gas turbines, refrigeration and air-conditioning equipment, and combustion. The book is divided into the following main chapters: Energy in transition, Stored energy, Energy equations, Reversible processes and cycles, The Carnot principle, The absolute temperature scale, Entropy, Properties and property relations in solid, liquid and vapor states, Properties and property relations of ideal gases, Property and property relations of low-pressure gas and gas-vapor mixtures, Thermodynamic properties of non-ideal gases and vapors, Thermodynamics of combustion, Power-generation cycles of condensing fluids, Power-generation cycles of noncondensing fluids, Heat pump and refrigeration cycles, Flow of compressible fluids, Dynamic forces. Diagrams include a multipressure hygrometric chart for air and water vapor mixtures, enthalpy chart of humid-air mixtures and flow chart for adiabatic flow of ideal gases ($k = 1.40$).

It will always be a delicate question in teaching engineering thermodynamics to decide on what level of structure of matter should be chosen as basis of presentation. Authors apparently decided that the atomistic view and the kinetic gas theory were entirely outside the scope of their book and thus do not enter on relevant concepts as they manifest themselves in specific heats Cp, Cv, in gas constant R, and in the creation of pressure. Similarly, the third law of thermodynamics and the statistical nature of entropy are but mentioned, and besides combustion there is no further presentation of thermochemistry. Here the graduate student of thermodynamics would have to rely upon other sources.

Instead, authors have given a concise, clearly derived and defined presentation on the macroscopic level. A number of footnotes and condensed sections carefully explain the common hurdles in the lines of thought so common to the student of thermodynamics. However, the special delight of the book lies in its true emphasis on engineering application. This means, among other things, a dual presentation of steady flow and its associated losses from thermodynamic and dynamic viewpoints, which goes further and brings more light on practical flow problem than most other texts on thermodynamics. There is a good account of fundamentals of compressible flow with a newly developed flow chart and including a study of flow in jet-engine intakes, and several very complete analyses of various power machinery and related equipment—the steam turbine with several stages of feed heating and reheat, commercial and military gas turbines, internal-combustion engines, refrigeration plants, etc. These analyses, together with examples and problems and the facilities for determination of Cp and R of nonideal gases, give an excellent command of the power engineering, refrigeration and air-conditioning aspect, and here the graduate student and the designer, who wants a bird's-eye view of his work in a certain application, have little more to ask for in completeness and coverage of the subject and its fundamental relations to flow dynamics. Printing and paper are of high standard. The book certainly deserves widespread use.

J. R. Schnittger, Sweden

785. Domenicali, C. A., Irreversible thermodynamics of thermoelectricity, *Rev. mod. Phys.* 26, 2, 237–275, Apr. 1954.

786. Malmquist, L., A vapor-pressure equation for an extremely wide temperature range (in Swedish), *Kyltekn. Tidskr.* 13, 3, 38–42, June 1954. (This is a corrected version of AMR 7, Rev. 4011.)

A vapor-pressure equation is proposed with high accuracy in an extremely wide temperature range. The deviation from measurements is ±0.10% for water in liquid state and within the experimental error from ice point to −50 C. The vapor-pressure derivative deviates from tabulated values with ±0.18%. The equation involves a logarithmic singularity at the critical point, which seems to be very accurate for many substances. The constants of the equation have physical meaning: The critical temperature; the critical pressure; and two limit constants, one according to the behavior of the substance at the critical point and one to the behavior at absolute zero temperature. In the solid-state range the melting entropy constitutes a fifth constant.

From author's summary by C. E. Lenngren, Sweden

787. Levitt, L. S., Extreme pressures, I. A new pressure-volume relationship, *J. phys. Chem.* 58, 7, 573–576, July 1954.

Author proposes the following empirical p-v relation for gases, liquids, and metals at high pressures, $p = Ce^{B/v}$, where B and C are constants characteristic of the peculiar substance. Validity is claimed for gases at 1000 kg/cm², liquids above 5000 kg/cm², and solids up to 100,000 kg/cm.² Graphs of p vs. ln $(1/v)$ are

shown to be linear for many substances, and polymorphic transitions show clearly as discontinuities in the graphs.

R. A. Gross, USA

788. **Becker, R., and Döring, W., Kinetic treatment of the nucleation in supersaturated vapors,** *NACA TN* 1374, 43 pp., Sept. 1954.

The equations of the individual processes of self-nucleation are utilized through an electrical analogy to obtain the nucleation frequency. This process is shown to be shorter and less subject to error than that of previous investigators, since the appearance of indeterminant integration constants is completely avoided. With the nucleation frequences of crystals and spheres the Ostwald law of stages is reviewed and modified. In the final section, the general resistance image is discussed and mention is made of the relation of the electrical network and Volmer's formula.

From authors' summary

789. **Herivel, J. W., Thermodynamics of the two-fluid model of liquid helium II,** *Nature, Lond.* **174,** 4424, 322–323, Aug. 1954.

790. **MacGregor, C. A., Flow between nozzles in series with an isentropic work change,** *J. aero. Sci.* **21,** 6, 423–424, June 1954.

791. **Severns, W. H., Degler, H. E., and Miles, J. C., Steam, air and gas power, 5th ed.,** New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1954, vii + 502 pp. $6.50.

This edition differs somewhat from the previous edition. As a textbook for a basic course in heat power, it discusses a variety of related topics, covering each with adequacy as to quantitative relations and pertinent descriptions or illustrations. Admirable restraint is frequently shown in avoiding details, yielding the advantage of a text with less than 500 pages.

Reviewer believes the traditional lack of continuity of subject matter and of uniformity of approach in textbooks of this type to be a distinct disadvantage. This new fifth edition, to the reviewer's mind, suffers from this traditional fault.

E. J. McBride, USA

792. **Mordell, D. L., An experimental coal-burning gas turbine,** *Inst. Mech. Engrs. Proc.*, 10 pp., 1954.

Author describes the design and preliminary results of a coal-burning gas turbine using the exhaust-heated cycle. This cycle may be classified as a half-open cycle, passing only clean air through compressor and turbine (as does the closed cycle) and heating the working fluid by a direct-fired heat exchanger, using a cyclone burner as combustor. The first runs of an experimental 500-hp plant at the Gas Dynamics Lab. of McGill Univ., Montreal, were aimed at operating characteristics of the furnace (which required redesigning of the mixing section) and of the heat exchanger (where fouling was not found to be critical). Duration so far is 114 hr, including nine stops and starts. Results are encouraging but final conclusions must await a planned 500-hr run (now under way) to be followed by a complete inspection by stripping furnace and heat exchangers. W. Gumz, Germany

793. **Margen, P. H., Determination of economic steam cycle for nuclear power stations. Parts I, II,** *Engineer, Lond.* **198,** 5139, 5140; 112–115, 148–150, July 1954.

794. **Daniel, Vera, The thermodynamic approach to solid structure,** *Brit. J. appl. Phys.* **5,** 9, 305–311, Sept. 1954.

The various ways in which a theoretical approach to the problems of solids can be made fall roughly into three categories: the thermodynamic arguments based on consideration of bulk properties; the chemical point of view based primarily on the concept of atomic valence; and, finally, the physicist's method which uses the notions of band theory. The paper stresses the usefulness and significance of the thermodynamic approach which is illustrated in the following examples: long-chain crystals, higher-order transitions, ferroelectricity and antiferroelectricity, glassy state, and, finally, the thermodynamics of alloys, in particular of simple binary systems. R. Smoluchowski, USA

795. **Sakuma, S., Effect of thermal history on viscosity of Oosima-lavas (Elastic and viscous properties of volcanic rocks. Part 4),** *Bull. Earthq. Res. Inst., Tokyo Univ.* **32,** part 2, 215–229, June 1954.

Heat and Mass Transfer

(See also Revs. 579, 683, 707, 734, 784, 786, 791, 792, 845, 846, 848, 849, 861, 879, 882, 883)

796. **Bäckström, M., Refrigeration engineering [Kältetechnik],** Karlsruhe, Verlag G. Braun, 1953, xv + 649 pp., 373 figs.

This book on refrigeration engineering covers admirably in one volume an astonishing amount of information in the wide field of applied sciences which contribute to this engineering art. That is evident from the chapters into which the content is subdivided: 1 General introduction; 2 Freezing mixtures, brines, cooling media; 3 Survey on expansion—and evaporation—processes; 4 Vapor compressor cycle; 5 Piston compressors; 6 Refrigerants; 7 Flow of refrigerants, pipelines and valves; 8 Operation, automatic control, regulators, equipment; 9 Heat transfer; 10 Humid air, defrosting, weight loss, relative humidity of cold rooms; 11 Insulation; 12 Cooling requirements; 13 Unsteady heat flow processes; 14 Fast freezing of food; 15 Rotating, water ring, helical, turbo and injection compressors; 16 Sorption engines; 17 Dry ice; 18 Expansion processes; 19 Brief survey on electrical engineering. What cannot be recognized from this enumeration is the exceptionally well-organized presentation, the original way in which many problems are attacked, and the diversified viewpoints from which they are treated, the latter reaching from thorough discussion of the physical processes to engineering design consideration and to economic investigations.

The author has been teaching refrigeration engineering since 1928 at the Royal Institute of Technology in Stockholm, Sweden, was active for several years in the research division of the Electrolux Corp., and is consultant for several other companies in this field in Sweden. Published in Swedish in 1947, book was translated in 1953 into the German language by E. Emblock at the instigation of R. Plank.

In chapters 7 and 9–13, which probably are of particular interest to readers of this magazine, the book covers such diversified subjects as pressure drop in ducts and valves (presented in the form of nomograms), vapor formation by expansion, heat transfer on finned surfaces, relations between heat transfer and pressure drop, humidity flow through walls and membranes, an interesting calculation procedure of cooling towers based on American methods and Markel's theory, a very illuminating treatise on the physical principles of heat insulation, well-presented meteorological data and information on sun radiation, illustrative examples on unsteady heat flow, hydraulic analogs to study such processes (including freezing, melting, condensation). Even the Hilsch tube gets one page of discussion.

In writing a book like the present one, it is almost impossible

not to create the feeling that in some places an extension of the discussion would have made a subject more easily digestible. Many mathematical relationships and formulas are stated without derivation and, unfortunately, without references, which makes it rather difficult to go back to the original literature. In this sense, the book cannot be regarded as a textbook, but it contains a vast amount of information for anyone working in the field of refrigeration, presented so that it stimulates thinking on the different problems encountered. In this way it can be highly recommended, and a translation into English would certainly be a very valuable addition to the literature in this country.

E. R. G. Eckert, USA

797. Henning, F., Temperature measurements [Temperaturmessung], Leipzig, Johann Ambrosius Barth, 1951, 294 pp., 80 figs. DM 26.80.

Author has packed into this book much information on basic theory, instruments operation, and sources of errors for gas, liquid, and resistance thermometers, thermocouples, vapor pressure thermometers, and radiation instruments, plus discussion on the thermodynamic temperature scale, constant temperature baths, temperature calibration substances, and measurements based on physical changes such as temperature indicating paints. The extensive coverage makes for short discussion on each method; however, a comparatively large amount of space is given to radiation measurements. Many references are given. The concise yet simple explanation of the problems in temperature measurement and the wide coverage allows one to make a quick evaluation of measurement methods. Discussion is from a theoretical approach, and the practical details of installation and measurement technique (such as given by Baker, Ryder, and Baker in "Temperature measurements in engineering," John Wiley & Sons, New York, 1953) are not covered.

A. C. Mueller, USA

798. Giedt, W. H., A method of measuring rapidly changing surface temperatures and of calculating the surface heat transfer applied to a 40-mm gun barrel, Heat Transf. and Fluid Mech. Inst., 105–114; Univ. of Calif., Berkeley, June 30–July 2, 1954.

This paper presents a method for measuring rapidly changing temperature and heat transfer at a gas-solid interface, as in a 40-mm gun barrel. The analysis considers the barrel behavior during the expulsion of the round as that of a semi-infinite solid.

The thermocouple used to determine the temperature very near the bore surface is essentially an oxidized nickel wire securely gripped in a steel plug with a thin nickel plating on the tip forming the junction. Various treatments are necessary to prepare the thermocouple for its subsequent rugged usage. The experimental results are presented in graphical form.

C. R. Mischke, USA

799. Higgins, S. P., Jr., and Keim, J. R., A thermal sine-wave apparatus for testing industrial thermometers, ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-20, 11 pp.

Paper describes apparatus which provides thermal sine waves in a pipe to determine the frequency response of industrial temperature-measuring devices. Some test results are included and discussed to show the use of the apparatus. Water from two constant-temperature storage tanks flows to a mixing valve and then to a pipe section in which the temperature-sensitive elements are located. The actual water temperature and response of the test element are recorded on a two-pen strip-chart potentiometer. Frequencies are varied over a range of 0.2 to 30 cpm. Amplitude and phase relationships are determined by measurements on the strip-chart records. From authors' summary

800. Rosenthal, D., and Friedmann, N. E., The determination of thermal diffusivity of aluminum alloys at various temperatures by means of a moving heat source, ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-56, 14 pp.

Work describes the experimental procedure and instrumentation developed for metals of thermal diffusivity of 0.2 cm^2/sec and more. The method was applied to aluminum alloys 3S and 61S, commonly used for welding purposes. The diffusivity of both alloys showed little or no increase with temperature from 150 to 1000 F. The results proved that values of thermal diffusivity, averaged over a 100 F interval, can be determined easily to three significant figures. The reproducibility of individual results was largely independent of the velocity and intensity of the heat source and the wall thickness of the specimens. It was of the order of $\pm 2\%$ but the probable error could be substantially reduced by computing the average result from several successive runs.

From authors' summary by N. H. Polakowski, USA

801. Kraemer, H. F., and Westwater, J. W., Digital computer solution for heat transfer to temperature probes, *Indust. Engng. Chem.* **46,** 10, 2035–2037, Oct. 1954.

The fin equation, extended to include radiation to solid walls through a transparent gas, is solved numerically for a range of the variables pertinent to gas-temperature measurement. The gas temperature is calculated for known probe tip and wall temperatures. Heat transfer from the end face of the probe is included.

Close agreement (less than 0.3% difference) was found between the numerical solution and the approximate analytical solution given in a previous paper [West, W. E., Jr., and Westwater, J. W., title source, **45,** 2152–2156, 1953] modified by the method of Harper and Brown [Harper, D. R., and Brown, W. B., *NACA Rep.* 158, 1922] to include the effect of finite tip area.

W. Daskin, USA

802. Simmons, W. R., An electrical geometrical analogue for two-directional steady-state heat conduction with uniform internal heat generation, ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-49, 13 pp.

The familiar method of electrolytic analog, or of metal foil, is here altered in some ways: A conducting paper (Teledeltos, WUT) is glued on an insulating slab in those portions which correspond to the heat-generating sections of the thermal field. The silver paints on the opposite side of a slab and on the (isothermal) boundaries of the paper are attached to terminals of a d-c source. A standard resistance included in the circuit enables a simple calculation of temperature gradients. Sources of errors are discussed and two examples (circular cylinder and a rod with square heat sources) are quoted.

O. Maštovský, Czechoslovakia

803. Woolf, J. R., and Sibbitt, W. L., Thermal conductivity of liquids, *Indust. Engng. Chem.* **46,** 9, 1947–1952, Sept. 1954.

Thermal conductivity of 14 liquids, including water, has been measured and compared to existing data. The apparatus comprised an internally heated concentric cylinder arrangement immersed in a constant-temperature bath. Authors estimate errors at less than 2.5% except for three liquids where convection would make values about 2% high.

Data on water checked within measurement accuracy with previous work. Five liquids had not previously been studied. Reviewer believes the care and precision of these tests indicate reliability within the limits set by authors and exceeding that of much previous work. G. M. Ketchum, USA

804. **Gutman, L. N., On the calculation of transient heat flow in solid bodies** (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **15,** 99–136, 1953.

Numerical method for calculating temperature distributions and heat flows in one-dimensional, transient heat flow is presented. Other methods available are often only applicable to the finding of temperature distributions as functions of time if the temperature variation is given at a boundary of a conductor. Author's method can be used for other types of problems; e.g., to define the variation of surface temperature with time so as to produce a specified temperature variation inside the body, or so as to produce a specified rate of heat flow at some section in the body.

Author deals with semi-infinite bodies and simple and compound walls. Method is extended to deal with the temperature variations of a fluid adjacent to a body when the heat-transfer coefficient is known. Extensive numerical tables are given to facilitate computation of many practical problems.

Y. R. Mayhew, England

805. **Rizika, J. W., Thermal lags in flowing incompressible fluid systems containing heat capacitors,** ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-50, 23 pp.

System analyzed consists of an incompressible fluid flowing at constant rate through a pipe whose thermal capacity is finite. The external surface of the pipe is exposed through a uniformly distributed thermal resistance to a uniform, constant external temperature (T_t). For time less than zero the pipe and fluid temperature (T_0) are equal and uniform. At time zero a step change in the entrance temperature of the flowing fluid is imposed. A solution, attained by transform methods, gives the temperature of the fluid as a function of time and axial position. The special case of infinite external resistance (insulated pipe) is given special consideration and, although not indicated by the author, corresponds to the system treated by Schumann [*J. Franklin Inst.* **208,** p. 405, 1929] and others. A numerical example of application of the analysis is presented.

Author states that if the flowing fluid is a perfect gas, then the local time derivative of the temperature of the gas disappears from the differential equations describing the system. Reviewer believes that this statement is erroneous even though the derivative can be omitted from the equations with small error under conditions which will generally be satisfied by a gas. Reviewer believes that the criterion for omission of the derivative is that the time required for the fluid to flow the length of the pipe should be small relative to the ratio of the heat capacity of the pipe to the thermal conductance between pipe and fluid.

L. M. K. Boelter, USA

806. **Peterson, A. C., Madden, A. J., Jr., and Piret, E. L., Heat transfer from wires to gases. Maximum flow rates in thermal conductivity measurements,** *Indust. Engng. Chem.* **46,** 10, 2038–2040, Oct. 1954.

This experimental research is made on nickel wires of 0.0028 and 0.0100-in. diam, located in vertical glass tubes in order to determine the allowable flow rates of gas through conductivity cells for electrical gas analysis.

The result is that the Reynolds number of the flow must be less than about 100, because under this limit the heat loss from wire to gas occurs by conduction only.

C. Codegone, Italy

807. **Brevoort, M. J., and Rashis, B., Turbulent heat-transfer measurements at a Mach number of 3.03,** *NACA TN* 3303, 21 pp., Sept. 1954.

Turbulent heat-transfer measurements are obtained at Mach number 3.0 along the outside wall of an axisymmetric plug-type nozzle. Edge effects accompanying flat plate tests are eliminated without the presence of the more troublesome secondary flow in the boundary layer of two-dimensional nozzles.

Actual heat-transfer rate is relatively small as the initial stagnation temperature and initial wall temperature are nearly equal. Heat transfer is maintained, since the stagnation temperature is allowed to continually decrease throughout the run. Heat-transfer measurement is accomplished by measuring the wall temperature versus time. To establish the temperature potential, the measured wall temperature is used and the actual insulated temperature computed from the recovery temperature relation. Several values of the recovery factor are assumed and the correct value is taken as the recovery factor yielding a constant Stanton number versus time.

This method of data reduction is considered valid because of the small temperature differences involved. The results presented show reasonable consistency and are approximately 10% higher than predicted from theory of Van Driest. The ever-present difficulties of determining the Reynolds number also exist in this analysis. J. L. Harkness, USA

808. **Cole, J., and Roshko, A., Heat transfer from wires at Reynolds numbers in the Oseen range,** Heat Transf. and Fluid Mech. Inst., 13–23; Univ. of Calif., Berkeley, June 30–July 2, 1954.

The results presented deal with the heat loss from electrically heated wires in the range of Reynolds number less than unity, thereby extending previous work which deals mostly with Reynolds numbers in excess of unity. The authors present data obtained from fine platinum-rhodium wires in air, whose diameters correspond, at room conditions, to 100, 20, and 1.5 mean free paths. There is the possibility that molecular effects may be important in the light of the fineness of the wire, but it is not felt that the accuracy is sufficient to resolve these, and it appears that these effects are not as important here as often anticipated.

Authors compare their results with the prediction of Oseen and Stokes theory and the formula of King. Agreement and deviation are adequately discussed.

C. R. Mischke, USA

809. **Stine, H. A., Investigation of heat transfer from hot wires in the transonic speed range,** Heat Transf. and Fluid Mech. Inst., 25–37; Univ. of Calif., Berkeley, June 30–July 2, 1954.

The performance of a hot-wire anemometer as a sensing element for the parameters of flow is examined in the transonic range ($0.5 < M_n < 1.4$) with Reynolds numbers varying from 18 to 144 and Knudsen numbers varying from 0.005 to 0.10. The heat loss due to radiation was presumed negligible. The author does not state the difference in absolute temperature between the hot wire and wind-tunnel wall. He concludes in part that, for a given probe configuration, temperature loading, and range of flow variables, the Nusselt number is a single-valued function of free-stream flow conditions combined in the parameter group proportional to the Knudsen number. The author commendably

presents a table of estimates of accuracy of individual determinations—a distinct aid to the critical reader.

C. R. Mischke, USA

810. Etemad, G. A., Free convection heat transfer from a rotating horizontal cylinder to ambient air, with interferometric study of flow, Heat Transf. and Fluid Mech. Inst., 89–103; Univ. of Calif., Berkeley, June 30–July 2, 1954.

Free-convection heat transfer from a rotating horizontal cylinder in air was studied for a Reynolds number range of zero to 65,400, for a Grashof number range of 1.5×10^5 to 1.7×10^6, and a Nusselt number range of 7.8 to 179. The stability of flow around the rotating cylinder and the transition from laminar Couette flow to fully developed secondary flow were investigated with the aid of a Zehnder-Mach interferometer. The author relates Nusselt number to the other dimensionless parameters of the problem within the various ranges of Reynolds number. The results are clearly presented in graphical form. The interference photographs are of good quality. The secondary flow around the rotating cylinder was found to become turbulent at a Reynolds number of about 14,500. C. R. Mischke, USA

811. Hubbartt, J. E., Slone, H. O., and Arne, V. L., Method for rapid determination of pressure change for one-dimensional flow with heat transfer, friction, rotation, and area change, *NACA TN* 3150, 22 pp., June 1954.

In the development of this (approximate) method, the momentum equation was approximated and rearranged for a convenient solution employing charts. This report presents both the analysis involved in simplifying the momentum equation and the charts necessary for obtaining particular solutions. The charts provide a step-by-step solution which converges to an exact solution as the number of steps is increased. An illustrative example and comparison with more rigorous numerical solutions with conditions typical for air-cooled turbine blades are included. These comparisons show that the solution converges rapidly to provide good accuracy. From authors' summary by P. A. Libby, USA

812. Marco, S. M., and Han, L. S., A note on limiting laminar Nusselt number in ducts with constant temperature gradient by analogy to thin-plate theory, ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-46, 12 pp.

When the equations of equilibrium for laminar flow in a channel are combined with the equation of heat transfer by convection from uniformly heated or cooled walls with constant axial temperature gradient, one obtains, as a result, a similar equation to that of deflection of thin plate subjected to a uniform lateral load and simply supported along the edges. The solution for small deflections of thin plates is known and, after matching boundary conditions, the temperature field is determined. Distributions of local film coefficients and Nusselt numbers are evaluated in the channels. S. Eskinazi, USA

813. Kavanau, L. L., Heat transfer from spheres to a rarefied gas in subsonic flow, ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-52, 14 pp.

Experimental over-all average heat-transfer coefficients for spheres in a subsonic air stream are presented for the slip-flow region in the range of Mach number M and Reynolds number Re (based on diameter), $0.1 \leq M \leq 0.69$ and $1.75 \leq Re \leq 124$. A simplified analysis is presented which yields the convective heat-transfer coefficient for a rarefied gas by means of a correction to the continuum coefficient at the same Reynolds number. Comparison of this analysis is made with an existing theory for cylinders. An expression for the nondimensional over-all average heat-transfer coefficient for spheres in a rarefied subsonic flow is given. From author's summary by M. J. Goglia, USA

814. Sänger, E., Gas kinetics of convective heat transfer and fluid friction on reflecting surfaces (in German), *Z. Naturforsch.* **9**, 5, 410–418, May 1954.

Author gives, in closed form, expressions for the contribution to the heat transfer and friction for three processes which can occur at the boundary with free-molecule flow: (1) Molecules adsorbed, (2) molecules diffusely reflected, and (3) molecules specularly reflected. Starting a light analogy, author assumes that molecules arriving at a rough surface with angle of incidence $\alpha \leq \alpha_k$ will be specularly reflected, and molecules arriving with $\alpha > \alpha_k$ will be diffusely reflected. The critical angle α_k is given by $\sin \alpha_k = h/mw\xi$ where h is Planck's constant; m mass of incident particle; w velocity of incident particle; ξ surface roughness of wall. Using Maxwellian distribution, author then calculates fraction of total molecules (per unit time, unit area) which are specularly reflected from a wall for a gas with no mean motion and for a gas with a mean velocity relative to the solid surfaces. The heat transfer and wall shear stress are calculated.

Reviewer feels that results are interesting despite the fact that they have little immediate engineering application in view of the fact that the minimum wall roughness required for specular reflection is of the order of 10^{-8} inches, much smaller than will occur in practice with high-altitude high-speed missiles.

W. Daskin, USA

815. Horton, W. H., Laboratory simulation of kinetic heating, *Aircr. Engng.* **26**, 303, 138–144, May 1954.

Paper reviews and compares the methods of kinetic heat simulation which may be used simultaneously with normal loading in structural tests of aircraft or components. Basic data on the quantities involved in, and the limitations of, the various techniques are given. An extensive bibliography of current literature on heat technology is provided. From author's summary

816. Morey, R. E., Bishop, H. F., and Pellini, W. S., Heat transfer characteristics of metals in shell molds, 58th AFS Ann. Meet., Prepr. 54–63, 6 pp., May 1954.

Solidification characteristics of metal cast into shell molds with backup are similar to those of sand castings. Without backup, differences dependent on specific conditions may develop.

From authors' summary

817. Perry, K. P., The heat transfer by convection from a hot gas jet to a plane surface, *Chartered mech. Engr.* **1**, 4, 207–208, Apr. 1954.

818. Uberoi, M. S., and Corrsin, S., Diffusion of heat from a line source in isotropic turbulence, *NACA Rep.* 1142, 29 pp., 1953.

Supersedes article reviewed in AMR 6, Rev. 226.

819. Pinkel, B., A summary of NACA research on heat transfer and friction for air flowing through tube with large temperature difference, *Trans. ASME* **76**, 2, 305–317, Feb. 1954.

Results are summarized of experimental and analytical studies performed by the NACA to determine the heat-transfer and friction coefficients for the flow of air through tubes with large difference in temperature between tube wall and air, (a) for smooth tubes of circular cross section; (b) for tubes of noncircular cross-sectional shapes; and (c) for tubes with various degrees of surface roughness. The experiments for the smooth tubes of circular cross

section cover a range of tube-wall temperature from 535 R to 3050 R, inlet-air temperature from 535 R to 1500 R, Reynolds numbers from 1000 to 500,000, exit Mach numbers up to 1, and tube length-to-diameter ratios from 15 to 120. Methods of correlating these data are discussed. The tubes of noncircular cross-sectional shape, namely, (a) square, (b) rectangular, and (c) triangular, were investigated at tube wall-to-air temperature differences up to 1200 F and Reynolds numbers between 2500 and 250,000. Three degrees of surface roughness, obtained by machining square threads into the inner surface of the tube, were investigated for temperature differences between the air and tube wall up to 1500 F and Reynolds numbers from 1000 to 350,000.

From author's summary

820. **Willoughby, A. B., Absolute water flow calorimeter for the measurement of intense beams of radiant energy,** *Rev. sci. Instrum.* **25, 7, 667–670, July 1954.**

Paper describes a pyrheliometer to measure convergent thermal radiation beams of flux densities ranging between 5 and 300 cals/cm²/sec. Instrument comprises two identical blackened water-cooled cylinders arranged to be heated electrically on the inside. Cooling water flows equally between the two cylinders and the temperature difference between the two outflowing streams is measured by a differential thermopile. One cylinder is irradiated by the beam to be measured while the other is heated electrically until a null is obtained. The function of the cylinders is next interchanged. It is shown that the radiant flux density can be obtained in terms of the aperture areas of the cylinders and the electrical power consumed under null conditions to heat the cylinders. Instrument takes about 15 minutes to obtain the two necessary nulls, but can be used to calibrate other simpler quicker secondary calorimeters. M. A. Saleh, Egypt

821. **Umur, A., Parmelee, G. V., and Schutrum, L. F., Measurement of angular emissivity,** *Heating, Piping, & Air Conditioning* **26, 11, 135–140, Nov. 1954.**

The relationship between emissivity and angle of emission of paints, oxidized metals, and roofing asphalt has been studied with a radiometer having a narrow field of view. It was found that all surfaces showed substantially no change in emissivity for angles of emission between perpendicular to the surface and about 50° from perpendicular. For larger angles, the surface emissivity decreased as the angle increased, with the exception of oxidized copper. In this case, emissivity first increased as the angle increased and then decreased with further increases in the angle of emission. Except for the oxidized copper the hemispherical emissivity was found to be approximately 95% of the normal (perpendicular) emissivity. Details of the experimental procedures and the method of correcting for stray reflections are described.

From authors' summary

822. **Price, P. H., and Smith, D., Heat transfer from a gas between parallel planes to its surroundings,** *Fuel* **33, 3, 302–310, July 1954.**

Calculations are made of the heat transfer from both gray and real nonluminous gases in a geometrically simple system. It is found that the gray gas assumption may predict heat-transfer rates approximately twice those found for a nonluminous gas. A formula is derived for the heat transfer from a real gas, and tables are given of the ratio of heat transfers calculated under the two different assumptions.

From authors' summary by E. S. Cohen, Holland

823. **Day, R. P., Hopton, R. L., and Schmidt, A. C., A high-speed air-driven shutter for controlling exposures to a convergent beam of high-intensity thermal radiation,** *Rev. sci. Instrum.* **25, 7, 654–660, July 1954.**

Paper describes an electrically controlled air-operated automatic shutter to deliver square-wave pulses of radiation from converging beams of intensities of about 5 cal/cm²/sec. Shutter is made of two metal blades moving in the same direction in the same plane to allow a somewhat uniform exposure of target to falling energy. Blades are adequately arranged to avoid clash and excessive heating and to minimize rebound and lag. Exposure times range between 0.07 and 5 sec, but larger times can be obtained manually. The shutter opens or closes in less than 0.01 sec and the total energy delivered during this period is below 10% of the total energy delivered during the time of uniform exposure. Device runs smoothly for approximately 7000 exposures and consumes, approximately each 2000 exposures, 200 cu ft compressed air at 1800 psi. M. A. Saleh, Egypt

824. **De Corso, S. M., and Coit, R. L., Measurement of total emissivities of gas-turbine combustor materials,** ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-26, 16 pp.

Total emissivities of several materials are measured by a thermopile viewing alternately a black-body source and test specimen, both at the same temperature, through an aperture of fixed dimensions. Data are presented showing the emissivity of several metals (nichrome, Inconel, Type 310 stainless steel, etc.) and ceramic coatings as functions of temperature, surface treatment, and previous history of the material.

E. S. Cohen, Holland

825. **Aronson, D., Heat exchanger design—Relationship between heat transfer effectiveness and pressure drop,** Heat Transf. and Fluid Mech. Inst., 115–126; Univ. of Calif., Berkeley, June 30–July 2, 1954.

Author relates heat-transfer effectiveness and pressure drop for optimum design. His position is that the value of the heat recovered or removed in a heat exchanger depends upon the power-generating or power-consuming equipment associated in the cycle with the heat exchanger. The cases of a regenerator for a gas turbine and an intercooler for a compressor are illustrated. The optimum balance between heat transfer and pressure loss have been considered for three situations:

(1) Fixed total heat-transfer area; variable fluid-flow cross-sectional area.

(2) Fixed fluid-flow cross-sectional area; variable total heat-transfer area.

(3) Fixed flow-path length and cross-sectional area; variable total heat-transfer area.

The effect of pressure loss was considered only as it changed the plant thermal efficiency. The reduction in the power output of a given size plant was not taken into account. The "optimum" which allows for reduction in plant output will be at a lower pressure drop than that obtained by maximizing the plant thermal efficiency. Optimum values of $\Delta P/P$ and associated variables are given in tabular and graphical form.

C. R. Mischke, USA

826. **Derjagin, B. V., Goufman, I. N., Amelin, A. G., and Levi, S. M., Theory of thermogradient drying of thin-film materials** (in Russian), *Dokladi Akad. Nauk SSSR (N. S.)* **92, 4, 759–762, Oct. 1953.**

Authors describe a method for drying thin sheets by placing sheet with wet film between a heat-radiating screen and a cold

condenser plate. Thermal gradient perpendicular to film surface sets up circular air-convection currents between sheet and condenser, carrying moisture to the condenser. From similarity of mass and heat transfer, authors derive a relation for rate of moisture transfer in terms of nondimensional parameters. Only one experimental value is given, and this is twice as large as that predicted. Authors explain discrepancy qualitatively by discussing (a) travel of dust particles which always move in direction of temperature drop, carrying with them additional moisture, and (b) effect of supersaturation. Y. R. Mayhew, England

827. Van Camp, W. M., and St. Clair, C. R., Boiling from wires with emphasis on transition phenomena, ASME Fall Meet., Milwaukee, Wis., Sept. 1954. Pap. 54—F-33, 12 pp.

Paper deals with boiling of ethyl alcohol from horizontal platinum wires at atmospheric pressure. Emphasis is placed on the processes immediately preceding and following the onset of nucleate boiling. New experimental evidence is presented which further substantiates the fact of the realization of a fairly large liquid superheat when a pure liquid is slowly heated by a clean surface. Once boiling is established, however, sufficient mechanical disturbances in the form of turbulence considerably reduce the superheat required to maintain a steady-state process of bubble formation. Similar results are reported by Corty and Foust [AIChE Preprint no. 1, Dec. 1953], and this has been called the "hysteresis" effect.

Reviewer believes paper to be important experimental contribution to the literature on boiling with specific reference to the metastable states of the liquid. J. A. Clark, USA

828. Güth, W., A cinematograph used to observe the details of the condensation of water vapor (in German), *Akust. Beihefte* **4,** 1, 445–455, 1954.

As an elucidation of cavitation bubble collapse phenomena, air-free water vapor of 0.5 to 1.5 atm is ejected from nozzles of 0.3, 2.2, and 7-mm diam into cold water, and bubble condensation and rebound are photographed at rates of 42,000–65,000 pictures per sec, both directly and by schlieren method, the latter for visualization of shock-wave radiation at the implosion. The development of the camera, including its rotating mirror, lens system, stationary film, and regulated intermittent light source, is fully described, mentioning the insufficient intensity of the latter for possible higher frequencies. While author's analysis of pictures finds reasonable agreement with Rayleigh, reviewer questions suitability of experiment because of lack of bubble sphericity and widely different vapor and liquid temperatures at the start of collapse. Evidently author is not familiar with the camera, built on similar principle but with different light source and regulation, which photographs cavitation bubbles generated by sound waves at a picture rate of 10,000 per sec, improved since to 400,000 per sec [Albert Ellis, "Observations on cavitation bubble collapse," California Inst. of Technology, Hydrodynamics Rep. no. 21-12, Dec. 1952]. A. Hollander, USA

829. Heywood, H., Solar energy for water- and space-heating, *J. Inst. Fuel* **27,** 162, 334–347, July 1954.

Characteristics of solar radiation, its transmission through the atmosphere, and the calculation of incident radiation on inclined surfaces are reviewed. The operation of flat-plate collectors is described and analyzed somewhat casually. Calculated performance data are of doubtful value because of lack of rigor. Experimental data are presented on flat-plate collectors with thermosyphon water circulation located in the London (England) area, together with correlations with incident radiation and temperature of operation. Solar-house research in the United States and possible use of solar energy in climates of more favorable solar weather are discussed. A. Whillier, South Africa

830. Conn, W. M., A note on the utilization of radiant energy from the sun in rockets, *Amer. J. Phys.* **22,** 5, p. 341, May 1954.

Without accompanying quantitative data the proposal makes a plausible story. However, had the author taken the trouble to compute the horsepower involved he would never have written the note. For although temperatures of many thousand degrees may be obtained with relatively small reflecting-type solar collectors, the actual number of Btu or horsepower involved is negligibly small compared to rocket power requirements.

A. Whillier, South Africa

831. Telkes, Maria, Solar thermoelectric generators, *J. appl. Phys.* **25,** 6, 765–777, June 1954.

A review of the literature and patents is presented which refers to the direct conversion of solar energy into electrical energy by means of thermocouples and thermopiles. Physical characteristics, thermoelectric power, and thermal conductivity were determined for Chromel, P-constantan, bismuth alloys, and ZnSb containing small amounts of added metals. Optimum characteristics of flat-plate-type collectors of solar energy have been evaluated in combination with thermocouples designed for maximum energy conversion. Using flat-plate collectors with 2 glass panes, an efficiency of 0.63% was obtained with ZnSb-type alloys in combination with a negative Bi-alloy. Calculations indicate that, with 4 panes, an efficiency of 1.05% may be attained. The use of lenses for concentrating solar energy increased the efficiency to 3.35%. Maximum allowable cost of thermoelectric generators has been evaluated by comparison with present methods of electric power generation. Solar thermoelectric generators may find use in the tropics as they do not contain moving parts and require very little attention. Further development is needed to determine their economic value. W. M. Conn, USA

832. Jaske, R. T., Large scale heating with atomic energy, *Heating and Ventilating* **51,** 11, 77–81, Nov. 1954.

833. Dorsch, R. G., and Brun, R. J., Variation of local liquid-water concentration about an ellipsoid of fineness ratio 5 moving in a droplet field, *NACA TN* 3153, 68 pp., July 1954.

Water-drop trajectories about an ellipsoid are computed, and the degree of concentration of water drops is determined at various points in proximity to the body. The data indicate that at a given body station water-drop concentration varies considerably with distance from the body surface. Under some conditions, it has been determined that local concentration may even be several times the free-stream value. Results, presented graphically, are applicable quantitatively to bodies geometrically similar to the ellipsoid investigated. Qualitatively, the results should be helpful in choosing the location of, or in determining anti-icing requirements for, water or ice-sensitive devices that protrude into the air stream from an aircraft.

N. R. Bergrun, USA

834. Brun, R. J., Gallagher, Helen M., and Vogt, Dorothea E., Impingement of water droplets on NACA 65A004 airfoil at 8° angle of attack, *NACA TN* 3155, 27 pp., July 1954.

The trajectories of droplets in the air flowing past an NACA 65A004 airfoil at an angle of attack of 8° were determined. The amount of water in droplet form impinging on the airfoil, the area of droplet impingement, and the rate of droplet impingement per

unit area on the airfoil surface were calculated from the trajectories and presented to cover a large range of flight and atmospheric conditions. These impingement characteristics are compared briefly with those previously reported for the same airfoil at an angle of attack of 4°.

From authors' summary by N. R. Bergrun, USA

Combustion

(See also Revs. 711, 712, 792, 824)

835. **Evans, Marjorie W., Current status of problems of combustion,** Heat Transf. and Fluid Mech. Inst., 39–49; Univ. of Calif., Berkeley, June 30–July 2, 1954.

Author discusses briefly the current status of combustion problems. She describes the physics and chemistry of gaseous deflagrative processes, then turns to the specific cases of one-dimensional steady-state flames, incipient flames, nonisotropic flames, turbulent flames, and pulsating flames. The discussion is lucid and unencumbered by frequent algebraic allusion.

C. R. Mischke, USA

836. **Zabetakis, M. G., Furno, A. L., and Jones, G. W., Minimum spontaneous ignition temperatures of combustibles in air,** *Indust. Engng. Chem.* **46,** 10, 2173–2178, Oct. 1954.

This work describes a very simple technique for the determination of the minimum ignition temperature of any combustible (gas, liquid, or solid) in air. An empirical correlation is found between the ignition temperature and the "average chain length" of the paraffin hydrocarbons, which are consequently grouped in two categories according to whether the value of their average chain length lies under or above five.

From the time lag before ignition at different temperatures, authors calculate an activation energy which, however, does not remain constant over the whole temperature range. A very large number of combustibles have been tested.

A. Van Tiggelen, Belgium

837. **Thorpe, M. L., and Browning, J. A., Lateral blowoff of a Bunsen flame,** *Indust. Engng. Chem.* **46,** 10, 2203–2205, Oct. 1954.

The reaction of a Bunsen flame to a secondary stream of air has been investigated. The stability limits are plotted showing the effects of flame tube velocity, secondary stream velocity, and Bunsen tube angle. The effect of the presence of a thin plate at the end of the flame tube is also shown.

E. C. Wilkerson, USA

838. **Golitzine, N., The flame stability limits of a baffle in a hot, fast, gas stream with kerosene fuel,** *Nat. aero. Establ. Canad.* LR 88, 7 pp., Dec. 1953.

Air-fuel ratio burning limits with a nonhomogeneous mixture were measured. Simulating some of the conditions in the Derwent V turbojet engine, a stream velocity of 455 fps and a temperature of 630 C were used. A preburner consuming part of the air was used for heating. A $1^1/_2$-in. disk flameholder inside a 5-in.-diam duct and a $6^1/_2$-in. long tailpipe were used.

Moving a single centrally located fuel injection point from 1 to 32 in. upstream from the baffle shifted the burning range to the rich side. At 32 in., the rich limit was 0.022.

Moving four fuel injection points, located 32 in. upstream, outward radially had the same effect. A mixture richer than stoichiometric was burned.

A combination of the five fuel injection points gave fuel/air burning limits from 0.0041 to 0.0526.

Reviewer believes that, for practical use, the results are limited by the short tailpipe. Where such short tailpipes are used, only a minor fraction of the fuel is burned and burning is usually very smooth. Where burning is complete within the tailpipe, perturbations caused by burning (roughness) may greatly decrease the burning limits.

E. E. Frost, USA

839. **Manton, J., Von Elbe, G., and Lewis, B., Burning-velocity measurements in a spherical vessel with central ignition,** Fourth Symp. (International) on Combustion, 358–363, 1953; Baltimore, Md., Williams & Wilkins.

Burning velocities have been measured for stoichiometric ethylene, methane, and propane mixtures with air using a bomb 15.295 cms radius with simultaneous measurements of pressure and flame growth with time. The earlier treatment of Fiock has been extended to give an independent check calculation of burning velocity. Preliminary experiments were made varying ignition energy and spark gap to insure that the flame growth was spherical and free from cell structure. The results at atmospheric pressure appear to be highly accurate and self-consistent, giving values in agreement with the best determination by other methods. The work marks a definite refinement of the bomb technique for burning velocity measurements.

N. P. W. Moore, England

840. **Moore, F. K., and Maslen, S. H., Transverse oscillations in a cylindrical combustion chamber,** *NACA TN* 3152, 25 pp., Oct. 1954.

Authors first consider periodic perturbation of one-dimensional compressible flow with heat addition (small Mach number), and obtain mode shape. Next they consider heat addition in small annulus (to simulate flame in wake of holder) with temperature-dependent reaction rate, and determine stability. The amplification rate is found as a function of mode and annulus position. The effect on stability of a time lag between heat release and temperature perturbation is discussed. It is also shown that transverse waves in a pipe have a permanent form to second order in the wave strength.

J. A. Fay, USA

841. **Cheng, S.-I, High-frequency combustion instability in solid propellant rockets. Parts I, II,** *Jet Propulsion* **24,** 1, 2; 27–32, 102–109, Jan.-Feb., Mar.-Apr. 1954.

Using small perturbation theory, the combustion stability in rockets having cylindrically shaped solid propellants is analyzed. Combustion reaction is assumed to lag the primary decomposition of the propellant, the time lag and decomposition rate being proportional to the nth and mth power of the pressure, respectively. For each geometrical configuration of the flow and boundaries, author determines a minimum value of the stability parameter $S = m - (n/2)$ below which combustion is stable. For tubular grain propellants burning on the inside, the spiral mode of oscillation is the least stable, with $S = 0.5$ or more. Other modes (radial and longitudinal) are more stable. Rod grain and rod in tube-grain propellants are more stable than tubular type for same mode. The effect on stability of changing geometry as propellant burns is also shown.

J. A. Fay, USA

842. **Fouré, C., Formation and deposits of carbon in the combustors of aircraft gas turbines** (in French), *AGARD Mem.* AG16/M10, 21 pp., May 1954.

843. **Graves, C. C., and Melvin, G., Some aspects of combustion of liquid fuel,** *AGARD Mem.* AG16/M10, 12 pp., 14 figs., May 1954.

The combustion of liquid sprays is considered in terms of such

individual processes as fuel spray spreading and evaporation. In addition, the efficiency of combustion of liquid fuels in turbojet combustors as affected by fuel volatility, spray characteristics, and the burning rate of single drops is treated.

From authors' summary

844. Burgoyne, J. H., and Cohen, L., The effect of drop size on flame propagation in liquid aerosols, *Proc. roy. Soc. Lond.* **(*A*) 225, 1162, 375–392, Sept. 1954.**

Limits of flammability, nitrogen dilution limits, and burning velocities were measured for liquid aerosols. For droplet diameters below 10 microns, the suspension behaves like a vapor fuel. Above 40 microns, the drops burn individually, in their own air envelope, and one burning drop ignites adjacent ones, thus spreading combustion. A practical result is that the lower limit of flammability is reduced and the rate of burning increased for the larger drops. The burning rates and flame sizes of the discrete drops in the aerosol are compared with similar data for isolated single drops. The differences are attributed to the influence of adjacent droplets.

From authors' summary by M. Gerstein, USA

845. Raskin, W. H., and Robertson, A. F., An adiabatic apparatus for the study of self-heating of poorly conducting materials, *Rev. sci. Instrum.* **25, 6, 541–544, June 1954.**

A small automatic furnace has been designed for the study of the thermal decomposition of wood and other combustible materials. After a sample has been brought nearly to thermal equilibrium at any desired temperature, the furnace temperature control system is automatically changed to allow the sample to self-heat up to a temperature of 500 C with small external heat loss or gain. Weight changes of the specimen during the test are continuously monitored and recorded. The control system is designed to stop the operation automatically after the specimen temperature has increased to some previously selected level.

From authors' summary

846. Cashmore, W. P., Measurement and influence of preheat in the open-hearth furnace, *J. Iron Steel Inst.* **178, part 2, 112–121, Oct. 1954.**

The variations in preheat within a particular heat of an O.H. furnace are considered, and also trends with time within a campaign. It is shown that an increase of 100 C in the preheat leads to an increase in working rate of about 0.5 ton/hr and a reduction in fuel consumption of 2–3 gal/ton.

Comparison of the working rate and fuel consumption as functions of preheat for particular designs of single-uptake and double-uptake furnaces suggests that the former give better results for a particular preheat. However, this advantage is offset to some extent by the increased pickup of preheat due to the greater surface area of the brickwork in the uptakes in the latter, which results in a higher preheat for a given regenerator capacity. The apparatus and experimental technique used to effect the measurements are discussed. From author's summary

847. Bell, E. B., and Thomas, D., Radioactive measurement of valve leakage, infiltration, and blowout in open-hearth furnaces, *J. Iron Steel Inst.* **178, part 2, 122–126, Oct. 1954.**

A pulse of radon is introduced at the air intake of an O.H. furnace and consecutive gas samples are taken from the waste-gas culvert after the reversing valve. The samples are quantitatively assessed for radon concentration. Any leakage over the valve is detected in the first few samples and the radon completing the normal furnace circuit is detected in the later samples. The quantity of radon passing the sampling point is determined and the loss (blowout) is calculated. Infiltration is measured by the dilution of the radon in the gas stream.

From authors' summary

848. Thring, M. W., Flame radiation and open-hearth productivity, *J. Iron Steel Inst.* **178, part 2, 165–169, Oct. 1954.**

Equal fractional changes in heat transfer and chemical conditions produce about equal changes in over-all output of the O.H. furnace. Once the bath is flat, more than 90% of the heat transfer must be by radiation. These two facts make the study of flame radiation of great importance in raising O.H. productivity. The experiments carried out at Ymuiden in a specially designed furnace have shown that the length of a turbulent jet diffusion flame such as is used in the O.H. is governed by the distance to entrain the combustion air, and have related this to the jet momentum and hence the fuel or atomizing-agent pressure. With oil flames, accelerating the mixing greatly reduces the luminosity, while coke-oven gas flames are nonluminous at all lengths. Calculating the effects on the O.H. of applying the types of flame which the Ymuiden experiments have shown to be possible has shown that high emissivity is desirable even if it can only be obtained by delayed combustion. From author's summary

849. Huge, E. C., and Piotter, E. C., The use of additives for the prevention of low temperature corrosion in oil-fired steam generating units, ASME Ann. Meet., New York, Dec. 1953. Pap. no. 53—A-235, 39 pp.

Paper discusses results of dolomite additions to fuel oil to reduce pluggage and corrosion in boiler air heaters. Authors give their experience with this process at the Higgins Plant of the Florida Power Corporation. In addition, they report similar, but limited, experience at the Inglis Station of the Florida Power Corporation and the Kearny Station of Public Service of New Jersey. It is their opinion that the addition of dolomite definitely aids in keeping air heaters dry and clean, even when metal temperatures are below the dew point. They estimate the cost of this protection at approximately $^1/_4$ of a cent per barrel of oil. The authors anticipate reduction of flue gas temperatures of approximately 40 to 50 F with the use of this treatment.

This is a fine paper on a subject of considerable interest. However, caution should be exercised until more experience is obtained from a greater number of installations. This should involve experience with a variety of oils, burners, and boiler designs. W. E. Hammond, USA

850. Ramey, H. J., Jr., and Nabor, G. W., A blotter-type electrolytic model determination of areal sweeps in oil recovery by in-situ combustion, *J. Petr. Technol.* **6, 5, 35–39, May 1954.**

A blotter-type electrolytic model was utilized to prepare flow diagrams for a field test of the in-situ combustion process. It is pointed out that the areal sweep of a combustion pattern is similar to sweep patterns that would be developed at an infinite mobility ratio, which exists (approximately) across a combustion front because of the complete removal of liquids from the sand behind it.

The precision of the blotter method was tested by comparison with results obtained by other techniques and was found to be satisfactory. The blotter-type model will not furnish as much information as more elaborate and expensive potentiometric models, but its speed of operation and ease of construction make it a highly satisfactory tool to determine areal sweep patterns. A tabulation of sweep efficiency and mobility ratio is furnished for various well geometries. From authors' summary

Acoustics

(See also Rev. 840)

851. **Lighthill, M. J., On sound generated aerodynamically, II. Turbulence as a source of sound,** *Proc. roy. Soc. Lond.* (*A*) 222, 1148, 1–32, Feb. 1954.

Part I [AMR 6, Rev. 654] concerned building up a physical theory of aerodynamic sound production in general. In this paper the subject is specialized to the study of *turbulence* as a source of sound (aerodynamic "noise"), and a more quantitative approach, involving comparison with experiments (for subsonic and supersonic jets), is made.

The quadrupole distribution of part I is shown to behave as if it were concentrated into independent point quadrupoles, one in each "average eddy volume." In accordance with the developed theory, the sound field of each of these is distorted, in favor of downstream emission, by the general downstream motion of the eddy. This explains, for jet noise, the marked preference for downstream emission and its increase with jet velocity. For jet velocities considerably greater than the atmospheric speed of sound, the "Mach number of convection" may exceed 1 in parts of the jet. Although turbulence without any mean flow has an acoustic output (calculated to a rough approximation from Proudeman's results), nevertheless turbulence of given intensity can generate more sound in the presence of a large mean shear.

Author holds the good agreement of the experimental results, as regards total acoustic power output, with his dimensional considerations of part I, partly fortuitous. The quadrupole convection effect should produce an increase in the dependence of acoustic power in the jet velocity above the predicted U^8 law (U the mean exit velocity), but the experiments show another dependence below the U^8 law (proportional to about $U^{6.5}$ is more common). The explanation is suggested that, at higher Mach numbers, there may be *less turbulence*, because in the mixing region, where the turbulence builds up, it is losing energy by sound radiation (this in accordance with the slow rate of spread of *supersonic* mixing region).

A consideration of whether the terms other than momentum flux in the quadrupole strength density might become important in heated jets indicates that they should hardly ever be dominant. Author reemphasizes, however, that in presence of fluctuating forces between the fluid and a solid boundary, a *dipole* radiation will result (at least at low Mach numbers).

From author's summary by M. Schäfer, Germany

852. **Wilson, O. B., Jr., and Leonard, R. W., Measurements of sound absorption in aqueous salt solutions by a resonator method,** *J. acoust. Soc. Amer.* **26, 2, 223–226, Mar. 1954.**

Paper presents the results of measurements of the sound absorption in aqueous solutions of several salts. While magnesium sulfate is the salt of primary interest in this case, some results for sea water at different temperatures, solutions of magnesium acetate, zinc sulfate, and beryllium sulfate are given. The frequency range of the measurements is approximately 50 to 500 kc. Although the resonator method used is not very precise, it is the only known laboratory method which is able to give reliable absorption measurements in water and water solutions in this low-frequency range where the sound absorption in these liquids is extremely small.

From authors' summary

853. **Kolb, J., and Loeber, A. P., The study of a sound field by means of optical refraction effects,** *J. acoust. Soc. Amer.* **26, 2, 249–251, Mar. 1954.**

An optical effect of an ultrasonic field discovered by R. Lucas and P. Biquard, namely, the broadening of a slit image, can be computed in a simple way which is based on a method by Weiner. It is useful in the frequency range below 1 Mc/sec for the point-by-point study of the pressure distribution in a stationary sound wave. Photographic records of this distribution were made. A simple method of measuring the wave length is described.

From authors' summary by M. Greenspan, USA

854. **Wood, J. K., The acoustic resistance of a pipe orifice to steady-state fluid flow,** *J. acoust. Soc. Amer.* **26, 4, 492–494, July 1954.**

Steady-state flow data for a viscous, incompressible fluid are plotted as acoustic resistance against volume velocity extended to a volume velocity corresponding to a Reynolds number of one. The acoustic impedance at zero frequency is then equal to the resistance predicted from Poiseuille's equation for laminar flow. The value of the Poiseuille resistance depends on the effective length of the pipe which, in turn, requires a reliable value of the end correction. By using end corrections that have proven adequate for periodic flow, the computed resistance agrees with the experimentally measured resistance in the region where resistance is independent of volume velocity or flow for orifice diameters from 0.106 cm to 1.28 cm. The resistance-vs.-flow curve has a bend point at a Reynolds number of about 10 for all orifice diameters measured. The resistance depends on the flow beyond a Reynolds number equal to 10, increasing with constant slope.

From author's summary

855. **McCubbin, T. K., Jr., The dispersion of the velocity of sound in water between 500 and 1500 kilocycles,** *J. acoust. Soc. Amer.* **26, 2, 247–249, Mar. 1954.**

Dispersion of the velocity of sound was measured by simultaneously transmitting continuous trains of sound waves of the two frequencies through water. One transducer was used to generate the two signals, and a second transducer, which could be moved in the direction of the sound beam, received the signals. Dispersion was determined by measuring the change in the relative phase of the two received signals as the length of path between the transducers was varied. These measurements indicated that the velocity of sound at 500 kc was equal to the velocity at 1500 kc to within one part in 290,000.

From author's summary

856. **Yamamoto, N., New method of determining ultrasonic wavelength in liquid,** *Rev. sci. Instrum.* **25, 10, 949–950, Oct. 1954.**

A method for the rapid measurement of the velocity of sound in liquids is described. An ultrasonic grating is established in the liquid under investigation. Light from a narrow slit is diffracted in passing through the liquid. It is shown that the wave length of the sound can be measured by widening the slit until one order of the diffraction spectrum connects with the next. Results of measurements on several liquids are compared with those of other investigators.

From author's summary

857. **Litovitz, T. A., and Lyon, T., Ultrasonic hysteresis in viscous liquids,** *J. acoust. Soc. Amer.* **26, 4, 577–580, July 1954.**

The ultrasonic absorption coefficients for longitudinal waves in glycerol and pentachlorobiphenyl are measured over the frequency range from 7.5 to 70 Mc. The measurements are made in the range of viscosities from 10^5 to 10^7 poise so that the ultrasonic frequencies used are well above the main relaxation frequencies associated with viscous flow processes in these liquids. The results indicate that the absorption coefficient per cm can be

represented by the expression $\alpha = B + Hf$, where B and H are constants and f is the ultrasonic frequency. The constants B and H in both liquids are found to decrease with increasing temperature, exhibiting an "apparent" activation energy of about 24 kcal/mole and 12 kcal/mole for the pentachlorobiphenyl and glycerol, respectively.

It is concluded that the results found here indicate that both terms B and Hf found in α could best be explained by assuming that one or more distributions of relaxation times exist.

It is suggested that ultrasonic hysteresis in both liquids and solids have a common origin, indicating that the hysteresis effect in liquids is not related to the viscous flow mechanism causing the absorption maximum at lower frequencies and viscosities. A possible mechanism offered for the hysteresis loss is the coupling of the acoustic energy into heat energy due to the anharmonicities in the lattice structure. From authors' summary

858. Litovitz, T. A., Lyon, T., and Peselnick, L., Ultrasonic relaxation and its relation to structure in viscous liquids, *J. acoust. Soc. Amer.* **26,** 4, 566–576, July 1954.

Measurements of ultrasonic propagation of longitudinal waves in pentachlorobiphenyl were made over a large range of viscosity at frequencies in the range 7.5 to 52.5 Mc. The data at low viscosities demonstrated the presence of both shear and compressional viscous processes. Measurements in the relaxation region indicated that a single relaxation time theory could not explain the results. Several possible explanations are discussed. The data at very high viscosities showed a frequency independent absorption loss per wave length, which indicated the possible presence of a nonrelaxational type of hysteresis.

The thermal coefficient of the high-frequency velocity was measured and found to be about twice the coefficient of the low-frequency velocity. The thermal coefficients of the instantaneous elastic moduli are compared to the low-frequency elastic moduli. It was concluded that the differences in the temperature dependence of these moduli could be related to the changing degree of order in the liquid. From authors' summary

859. Pohlman, R., Methods of ultrasonic testing in the metal-cutting industry (in German), *Z. Metallk.* **45,** 4, 161–165, Apr. 1954.

In the case of supersonic practice, nondestructive testing of materials makes use chiefly of the pulse reflection method. Moreover, transmission methods offer considerable advantages in many cases. It has been assumed by Kruse that the resolving power of the transmission method is dependent on the solid shade of a defect. However, a verification of Kruse's theoretical considerations displays that the resolving power is much greater than what could theoretically be expected. A transmission apparatus with a frequency-modulated ultrasonic beam is described, having coupling pieces of different shapes in order to get the most favorable coupling in accordance with the geometric shape of the specimen. Examples are given for testing arrangements with different specimen (wires, sheets, turbine bodies, etc.).

O. Ruediger, Germany

860. Kearney, T. J., Uses of ultrasonics in degreasing processes, *J. acoust. Soc. Amer.* **26,** 2, 244–246, Mar. 1954.

Ultrasonics is one of the newest tools to be applied to metal cleaning. Through the years abrasives, soaps, compounded alkaline materials, and solvents have been used to remove soils from metals. Trichlorethylene Solvent degreasing has had a wide reception in industry since its introduction in 1930. The Detrex Soniclean process combines sound energy and trichlorethylene solvent degreasing for metal cleaning. This is accomplished by immersing especially treated barium-titanate transducers in chlorinated solvents producing cleaning results previously unobtainable. Crossrod, conveyorized equipment incorporating constant distillation and filtration of the solvent in the sonics chamber and providing a final vapor rinse and drying, is now producing as many as 8000 parts per hr in industrial plants.

From author's summary

861. Mattiat, O., The processing possibilities of ultrasonics, *J. acoust. Soc. Amer.* **26,** 2, 241–243, Mar. 1954.

Ultrasonic processing possibilities are limited mainly by the economic factors of high first cost of equipment and high power cost per unit of processed material. In addition, transducers suitable for large volume applications have only recently been developed. Processing possibilities which have led to industrial applications or which seem quite promising are reviewed. Among them are ultrasonic maturing of liquids, extraction, dispersing of dyes and pigments, emulsification, flotation ore dressing, degassing of water, oil and glass, soldering of aluminum, drilling, and cleaning of metal parts. From author's summary

862. Balachandran, C. G., Ultrasonic velocities in binary mixtures, *J. Indian Inst. Sci.* **36,** 1, 10–18, Jan. 1954.

Ultrasonic velocities and their variation with concentration have been measured for five binary mixtures, e.g., toluene-heptane, pyridine-acetic acid, pyridine-n-butyric acid, nitrobenzene-n-butyl alcohol, and methyl alcohol-benzene. From the observed value of the velocity, adiabatic compressibility was calculated for each mixture. The effect of compound formation and association on the compressibilities of these mixtures has been examined.

From author's summary

863. Mikhaĭlov, I. G., and Solov'ev, V. A., Absorption of ultrasonic waves in liquids and the molecular mechanism of volume viscosity (in Russian), *Usp. fiz. Nauk* **50,** 1, 3–50, May 1953.

Volume viscosity and the associated molecular processes are of great significance in leading to an understanding of the molecular mechanism of the liquid state, but few investigations have been made on this type of viscosity. Direct measurements can be made by determining the absorption of ultrasonic waves in liquids, and in this paper the work of a number of well-known investigators which has a bearing on the molecular mechanisms in liquids in this connection is critically examined. The high values of ultrasonic absorption obtained (super-Stokes absorption) lead to the conclusion that the molecular mechanism of volume viscosity is not completely clear, but if more suitable models could be made of the various relaxation processes, based on the theory of Mandel'shtam and Leontovich, for instance, and further work could be carried out to determine the variation of the ultrasonic absorption in liquids with temperature, then the experimental results of ultrasonic absorption could be used to study the molecular mechanisms of the liquid state.

Marie Goyer, England

Ballistics, Detonics (Explosions)

(See also Revs. 732, 754, 798)

864. Lindsay, J. C., and Masket, A. V., Ultra-speed transient dynamic analyzer for mechanics and ballistics, *Rev. sci. Instrum.* **25,** 7, 704–711, July 1954.

Author describes photoelectronic apparatus which has been used to measure simultaneously the depth of penetration, the speed, and the deceleration of a nondeforming small-caliber pro-

jectile as it moves through a plate of armor. The projectile passes perpendicularly across a thin parallel light beam of uniform intensity which is directed on a vacuum-type phototube. The output of the phototube is proportional to depth of penetration and can be differentiated to give signals proportional to speed and deceleration. Decelerations as high as 10^6 ft/sec^2 are measured with an average error of 2%. Complete circuit details and some applications are given. J. S Rinehart, USA

865. Allen, W. A., Two ballistics problems of future transportation, *Amer. J. Phys.* **21,** 2, 83–89, Feb. 1953.

The kinematics of two simple motions of a ballistic vehicle is considered with the resultant acceleration acting on the vehicle kept at a constant magnitude throughout the motion. The vehicle is assumed to be a particle. The first example considered is a vehicle constrained on the great circle of the earth. The second example is a vertically ascending rocket.

S.-I Cheng, USA

866. Roth, E., Calculation of trajectories of beam-riding guided missiles (in German), *ETH Zürich Prom. Nr.* 2220, 69 pp., 1953.

Assuming a constant target velocity, the radar beam moves in a plane. Differential equations for the resultant motion of the missile are written, connecting polar coordinates of missile position (r,θ) and a guidance angle β. The force for turning the rocket, as from deflection of an elevator or turning rocket-exhaust flow direction, is given by β. Since θ is known in terms of the target altitude and speed, the equations determine r and β. Method is to write r and β as double power series in the two parameters with coefficients unknown functions of time, substitute in the equations, and solve numerically. For given target altitude and speed, the appropriate program for β as a function of time is inserted and the missile launched.

Consideration is given to the oscillatory stability of the system and to the relation between bounds on β and beam-riding ability. Full details are given and a numerical example is worked out.

C. M. Ablow, USA

Soil Mechanics, Seepage

(See also Revs. 647, 698)

867. Gibson, R. E., and Henkel, D. J., Influence of duration of tests at constant rate of strain on measured "drained" strength, *Géotechnique, Lond.* **4,** 1, 6–15, Mar. 1954.

Theory shows that a fully drained condition is impossible to attain in a laboratory "drained" test run at a constant rate of strain. However, expressions which have been derived in this paper enable an estimate to be made of the duration of the test necessary to insure a certain closeness of approximation to the fully drained condition. The results of a number of drained triaxial and shear-box tests on three clays—carried out at various rates of strain—are shown to confirm, in a general way, the predictions of the theory.

The theory of consolidation indicates that, in practice, there is always a certain pore-water pressure left undissipated by the time that failure conditions have been attained in a laboratory "drained" test on a clay, and it has been shown that the magnitude of this undissipated pore-water pressure varies inversely with the duration of the test. When the coefficient of consolidation of the clay is known, the duration of the test necessary to insure that the pore pressure remaining at failure has a negligibly small effect on the measured strength may be calculated from simple equations which have been given in the paper.

From authors' summary by D. M. Burmister, USA

868. Kézdi, A., Is there an undisturbed soil sample? (in Hungarian), *Mélyépítestudományi Szemle,* **3,** 1, 23–28, 11 figs., 1953.

Results of laboratory tests carried out on "undisturbed" soil samples play an important role in the numerical evaluation of soil characteristics. It must be investigated whether and to what extent the present practice of taking undisturbed soil samples insures the intactness of the sample as well as the changes that may occur. An examination of the forces acting on the sample leads to the introduction of certain factors with the aid of which the disturbance occurring in the sample as well as in the sampler can be judged. Changes in the state of the sample are due to: the release of external stress, the change in stress condition, changes in the water content and voids ratio, the ruining of the soil structure, and the chemical effects. All these affect the compressibility and the uniaxial compressive strength of the soil. The various effects are illustrated by examples. As a result of the investigations, those conditions could be established which—if achieved simultaneously—permit the samples to be considered as practically undisturbed. They are: (1) the ratio of the original length of the sample and its length measured after taking should differ from unity only by a given small value; (2) no deformations, failure, or gliding planes and no discolored spots should appear on the surface or on a section of the sample; (3) the weight of the sample should not undergo changes during transportation, storage, or handling.

From author's summary

Courtesy of Hungarian Technical Abstracts

869. Mikhaĭlov, G. K., Application of extremely anisotropic soil patterns for approximate solution of some basic tasks on ground water flowing upon an impervious base (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **15,** 159–168, 1953.

Author takes into account two limit cases of anisotropy where, in the first, the permeability in the axis of anisotropy perpendicular to the impervious base equals zero and, in the second, to an infinite value. Assuming the validity of Darcy's law he gives solutions for (1) seepage from reservoir with vertical pervious side into dry soil, the reservoir water level being constant and the impervious base horizontal; (2) seepage from reservoir with constant water level through rectangular dam with inclined impervious base. The difference in the rate of flow for the two extreme anisotropies is, in case (1), 5.7% and in case (2), 16.4%. The evaluation of an accurate solution in such tasks is, therefore, possible on the base of only one of the two limit cases.

As an example, the evaluation of seepage from reservoir with inclined pervious side into dry soil is presented. Assuming the hydraulic gradient to be proportional to a power of speed or to be a parabolic function of the speed, writer in the same way deals with (1) seepage through a rectangular dam on horizontal impervious base, and (2) seepage to a well. In these cases also, the difference in the rate of flow for both extreme anisotropies does not exceed 17%. L. Šuklje, Yugoslavia

870. Vandepitte, D., The bearing capacity of pile foundations (in Dutch, with French summary), *Ann. Trav. publics Belg.* **106,** 4, 5, 6; 567–631, 755–800, 897–960, Aug., Oct., Dec. 1953.

The design of pile-supported footings is commonly based on the

assumption that each pile carries the same load, or that their bearing capacity is the sum of the same bearing values of each individual pile. Theoretical considerations and field test results lead to the conclusion that these assumptions are usually far from correct. Furthermore, the deformation of the bearing slab is, in general, not compatible with the yielding of individual piles. In chap. 1 the author compares the method of Nökkentved with his own method presented in this paper, by which he attempts to solve various more complicated problems in this field. Following assumptions are made in the method of Nökkentved: (1) The piles are hinge-connected with the slab; (2) the projection of settlement of each pile top on pile axis is proportional to the pile load; (3) the load-transmitting slab is assumed to be rigid, without elastic deformation. Nökkentved's method consists in determining three unknown values: horizontal and vertical displacement of the slab, and its rotation about a certain point O (called elastic centroid of the system). Furthermore, chap. 1 contains description of other similar methods as compared with Nökkentved's and his own method and their characteristics (Ostenfeld, Gullander, Ekvall, Fellenius, Hultin, Verschaeve, Schultze, Descans, Westergaard).

Chap. 2 describes author's method of "rotation center" based upon the same suppositions as the Nökkentved method. The author's unknowns are the coordinates x and z of the rotation center C of the slab and the angle of rotation. Individual pile loads are proportional to distances between the head of the pile and the center C, to the resistance coefficient EA/L, in which E is modulus of elasticity, A average cross-sectional area, and L length of the pile. Numerical example shows that this method offers simpler and quicker verification than that of Nökkentved. Also, a graphical application of this method is demonstrated. It is also possible to consider rigid restraint of the piles in the slab.

In chap. 3, author attempts to prove that the methods of Nökkentved and other authors do not permit estimating the actual bearing capacity of the pile foundations. In these methods it is implicitly admitted that the ultimate bearing capacity is attained when one of the calculated pile loads reaches the permissible resistance in compression or tension. Hence, it would be theoretically possible, as demonstrated in examples, to strengthen a certain foundation by eliminating one pile, and vice versa, which is not logical. In chap. 4, fundamentals of the author's method are subjected to further discussion: (a) Relation between the load of a pile and displacement of its head; (b) numerical example; (c) investigation of ultimate states which are statically possible; (d) investigation of ultimate states which are geometrically possible. In chap. 5, various theorems of determinate ultimate state under five different assumptions are thoroughly discussed (assumptions I to V). Chap. 6 refers to practical applications of graphical solution. Furthermore, theorems under three other assumptions (VI to VIII) are discussed and final conclusions are drawn. J. J. Polivka, USA

871. Holtz, W. G., and Gibbs, H. J., Engineering properties of expansive clays, *Proc. Amer. Soc. civ. Engrs.* **80,** Separ. no. 516, 27 pp., Oct. 1954.

Micromeritics

872. Jenike, A. W., Flow of solids in bulk handling systems, ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-34, 20 pp.

This attempt to develop a quantitative method of design for flow of bulk solids in bins, hoppers, and spouts is significant in the special attention that is given to arching or doming of the material.

The kernel of the paper is the proposed relationship between the "strength" of the bulk solids and the pressure to which they are subjected; the effects of impact pressure and vibrational pressure are distinguished from the static pressure of the material in the bin. The relationship has to be determined experimentally for each material and a method for doing so is described. It is shown how consideration of the obstructions to flow and to the development of static pressure leads to the possibility of calculating design data. Some practical devices for preventing large compacting pressures, such as the use of ledges and pressure breakers, are given. The conditions under which model bins can aid design are discussed briefly.

Reviewer considers the proposed relationship of "strength" with pressure may be oversimplified, but this cannot be settled until the experimental data referred to by the author become available. R. L. Brown, England

873. Craven, J. P.; Ambrose, H. H., The transportation of sand in pipes. I Full pipe flows, II Free-surface flow, Proc. Fifth Hydraulics Conf., June 9–11, 1952; *State Univ. of Iowa, Studies in Engng. Bull.* 34, 67–88, 1953.

Sediment transportation characteristics in a circular conduit were experimentally determined in terms of basic quantities. These basic quantities were fluid discharge, sediment discharge, pipe diameter, depth of flow, depth of sediment bed, and sediment particle diameter. Fluid properties were not considered. The sediment specific weight to fluid specific weight ratio was included in the graphical dimensionless presentation of results in a manner suggested by Shield's experiments.

The experiments included three separate studies as follows: (a) Transport characteristics with zero thickness of sediment bed at the condition of impending deposition; (b) transport characteristics with a sediment bed in a full pipe; and (c) transport characteristics with a sediment bed in a pipe flowing as an open channel.

The reviewer considers these papers invaluable to the engineer who is concerned with sediment deposition in pipes.

M. R. Carstens, USA

874. Khachatrian, A. G., Saturation of current by suspended particles and dynamics of silting (in Russian), *Gidrotekh. i. Melior.* no. 6, 35–50, June 1954.

Author objects to the habitual computation of mean hydraulic size of sediments and discusses the transporting capacity of stream, critical and excessive density of suspensions, and process of sedimentation. Computations are to be based on typical distribution of size of transported substances.

S. Kolupaila, USA

875. Wolff, E. R., Screening principles and applications, *Indust. Engng. Chem.* **46,** 9, 1778–1784, Sept. 1954.

Elementary principles of mechanical screening are discussed and applied to several types of gyrating and reciprocating screening machines.

Author concludes that the constant characteristics of their action make gyratory sifters suitable for high capacity, accurate screening of dry free-flowing materials of rather uniform shape and weight. For slightly coarser sieving the reciprocating machine with the guarantee of plenty of agitation and resistance to plugging is well suited to less free-flowing materials, e.g., wet and moist stocks and particles of heterogeneous size, weight, and roughness. G. H. Lean, England

Geophysics, Meteorology, Oceanography

(See also Revs. 699, 795)

876. **Verhoogen, J., Petrological evidence on temperature distribution in the mantle of the earth,** *Trans. Amer. geophys. Un.* **35,** 1, 85–98, Feb. 1954.

On the assumption that convection is an effective process of heat transfer in the mantle, petrological evidence suggests that the temperature at the core boundary fluctuates, in space and time, between a lower limit of about 1500 C and an upper limit of 2500 C. Generation of basaltic magma in the upper 100 km of the mantle is readily explained if the temperature gradient required to start convection does not exceed 0.6°/km, which is about twice the adiabatic value. Formation of uncommon magma types, such as anorthosites, may perhaps be explained by relatively small and momentary departures from conditions described. Implications of the convection hypothesis on the density distribution in the mantle are discussed briefly.

From author's summary

877. **Birch, F., Elasticity and constitution,** *Trans. Amer. geophys. Un.* **35,** 1, 79–85, Feb. 1954.

The principal facts contributing to modern ideas of the structure of the earth mantle are briefly reviewed. Particular attention is given to the problem of a physical interpretation of seismic velocities and their variations with depth, following a method discussed in detail in a recent paper by the author in the *J. Geophysical Research* ["Elasticity and constitution of the earth's interior"]. The principal conclusions are (1) that the mantle as a whole is not homogeneous; (2) that there may be a reasonably homogeneous layer between the depths of 900 and 2900 km, consisting of high-pressure phases, presumably of the composition of a ferromagnesian silicate; (3) that gradual changes of composition, of the proportion of high pressure phases, or both, take place in a transitional layer between the depths of 200 to 900 km. Discovery of the nature of this transitional layer is considered to be of crucial importance for dynamical geology and petrology.

From author's summary

878. **Blair, B. E., and Duvall, W. I., Evaluation of gages for measuring displacement, velocity, and acceleration of seismic pulses,** *U. S. Bur. Mines Rep. of Investigations* 5073, ii + 21 pp., Aug. 1954.

879. **Davies, D. R., A note on the two-dimensional equation of diffusion in the atmosphere,** *Quart. J. roy. meteor. Soc.* **80,** 345, 429–434, July 1954.

Lettau's "shearing advection term" is introduced into the equation of Sutton and Calder for two-dimensional diffusion, and a solution is obtained for an infinite continuous line source. The predicted values of cloud height and peak concentration are not significantly different from Calder's predictions, without the Lettau term, for a selected experimental verification. In his discussion, Lettau suggests that the continuity condition used by Davies is incomplete and that a revised analysis might give significantly different results. It should be pointed out also that the experimental data selected by Davies already showed near-perfect verification of Calder's predictions, so that inclusion of Lettau's term could scarcely lead to much improvement.

J. E Miller, USA

880. **Teichert, F., and Kühn, U., A microvariograph for registering short-period air pressure fluctuations** (in German), *Z. Meteor.* **8,** 5, 132–142, May 1954.

A microvariograph is constructed and tested which can register air pressure fluctuations of the order of 10^{-3} to 10^{-4} mm Hg and periods between 20 to $^1/_{12}$ cps. An aneroid capsule without spring of microbarograph and optical system of registering with a rotating mirror and photographic paper recorder are used. Sensitivity or frequency is changed or filtered by the use of air tanks and nozzles of various dimensions. Several records of barometric pressure fluctuations are reproduced which will indicate the states of air turbulence corresponding to weather conditions.

M. Sanuki, Japan

881. **Gumbel, E. J., Statistical theory of droughts,** *Proc. Amer. Soc. civ. Engrs.*, Separ. no. 439, 19 pp., May 1954.

Droughts are analyzed by the asymptotic theory of smallest values of a limited statical variate. The extremal probability paper used for floods is used for the logarithms of droughts. If the lower limit of the discharges is assumed to be zero the probability function of the droughts becomes a straight line. If the lower limit exceeds zero, the three parameters in the probability function are estimated by the method of moments. A given statistical criterion indicates whether or not the lower limit may be assumed to be zero. Observations on the droughts of 13 rivers analyzed by this procedure show a close conformance with the theory. Therefore, extrapolation is permissible if the basic conditions prevail.

From author's summary

882. **Griesseier, H., Flow in an isothermal atmosphere due to a forced periodic temperature change** (in German), *Z. Meteor.* **8,** 2/3, 42–51, Feb./Mar. 1954.

By the integration of systems of linearized hydrothermodynamical field equations, the title problem is treated. Forced temperature change on earth's surface is given as boundary condition in a form which is periodical both in space and time. As to heat supply, only vertical conduction by turbulence is considered and its magnitude is assumed to be proportional to vertical gradient of temperature.

For solving the six simultaneous linear equations, the ordinary method of deriving the characteristic equation is used; the determinant composed of the coefficients and derivative operators is equated to zero, assuming the form of solutions to vary exponently to the vertical. See also the review for Böhme's paper (see following review).

H. Arakawa, Japan

883. **Böhme, W., Thermically controlled circulation mechanism in a basically resting isothermal atmosphere** (in German), *Z. Meteor.* **8,** 2/3, 52–66, Feb./Mar. 1954.

Similar problem to Griesseier's paper (see preceding review) is treated. But instead of the temperature change itself, heat supply on earth's surface, which is assumed to be proportional to the vertical gradient of temperature, is given as boundary condition in a form which is periodical both in space and time. Frictional effect is considered in a simple form. Used method is almost similar to the method used by Griesseier. In both papers, only the mathematical forms of the solutions are presented, but results are not examined in the light of actual phenomena. Concerning the mathematical treatments, reviewer has no criticism, but at least for the large-scale phenomena the appropriateness of assumptjons used will be doubtful.

H. Arakawa, Japan

Lubrication; Bearings; Wear

(See also Revs. 654, 709)

884. **Kettleborough, C. F., Frictional experiments on lightly-loaded fully floating journal bearings,** *Austral. J. appl. Sci.* **5,** 3, 211–220, Sept. 1954.

Tests are described on a floating bush journal bearing in which

two independent oil films are interposed between the journal and bearing surfaces. Test results are compared with theory developed by Shaw and Nussdorfer [*NACA Rep.* 866, 1947]. Agreement between this theory and experimental results is only fair. Ratio of floating bush speed to journal speed is less than theoretical, while journal bearing friction is greater than that predicted by theory.

Friction in test bearing as measured includes friction loss in auxiliary bearings supporting test shaft. This is corrected for by dummy run with test bearing replaced by anti-friction bearing identical with those used to support the shaft. The order of magnitude of this correction is not stated so that it is not possible to judge its effect on the final results. Rather large changes are produced in the clearances due to thermal expansion, since the bush was of phosphor bronze and the journal and bearing of steel. This effect is presumably taken care of in the calculations but it also may account for some part of the difference between calculated and experimental results.

Author concludes that floating bush journal bearing operates at a lower temperature and with a lower friction loss than an equivalent journal bearing. The load capacity is reduced. Its main disadvantage is the failure of the floating bush to start always from rest when under load.

W. O. Richmond, Canada

885. Garkunov, D. N., and Kragelsky, I. V., Effect of the ratio of hardness of rubbing surfaces on slipping conditions between machine parts in contact, *Nat. sci. Found.* tr-178, 4 pp., Jan. 1954; *Doklady Akad. Nauk SSSR (N. S.)* **91,** 5, 1085–1088, Aug. 1953.

Study of frictional forces and damage to surfaces when (1) a hard metal slides on a soft surface and (2) when a soft metal slides on a hard surface; in both cases, area of slider is less than area of stationary member. Areas of contact, unit stress, and maximum frictional force are given for different loads for the following pairs of materials: copper and aluminum; steel and aluminum; and chromized steel and steel for conditions (1) and (2) above. Reduction in frictional force and in abrasion of the surfaces is greatest when softer surface slides on the harder surface. Similar work is also described in "The friction and lubrication of solids" by F. P. Bowden and D. Tabor, chap. 4 [AMR **4**, Rev. 4673].

C. F. Kettleborough, Australia

886. Westphal, R. C., and Glatter, J., The wear and friction properties of materials operated in high-temperature water, ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-13, 14 pp.

Purpose of the investigation is to discover combinations of materials which can be used successfully for bearings operating in 500 F water. Test apparatus is described which was constructed for the evaluation of the wearing properties of materials combinations under this condition. Representative results are reported which cover the range of experimental values observed. These results are discussed with regard to the influence of several variables upon the mechanisms of wear. A brief study of friction and solid film lubricants is included. From authors' summary

887. Spengler, G., Molybdenum disulphide as lubricant: Experiments and applications (in German), *ZVDI* **96,** 20, 683–687, July 1954.

Results are reported of friction and wear tests on samples of sintered material containing 5% copper and from 0 to 35% molybdenum disulphide, the remainder being silver. Friction tests at various speeds showed a falling off in coefficient of friction with increasing content of MoS_2. In general, coefficient of friction fell from about 0.3 with no MoS_2 to about 0.17 with 35%. Experiments were carried out at various loads but, despite some scatter in the results, intensity of loading appeared to have little effect on the results.

Wear tests, wherein the increase in area of contact of a hemispherically ended slider of the sintered material during a test of one hour's duration under a load of 519 g at a speed of 1524 m/min. was measured, showed an optimum MoS_2 content of about 8%. Figures for loss of weight confirmed the existence of this optimum.

The paper reviews other experimental work on the use of MoS_2 in industry. The author considers that development is still to be expected and that the best combination of materials containing MoS_2 will depend on the circumstances of the particular application. F. T. Barwell, Scotland

888. Tichvinsky, L. M., Models for the study of lubrication phenomena, "Mémoires sur la mécanique des fluides," *Publ. sci. tech. Min. Air. Paris,* 339–350, 1954.

Several models of lubrication mechanisms are described as teaching aids for courses in lubrication. Included are "plain slider bearing," "plain journal bearing," "performance of oil rings," "viscosity pumps," "air-film lubrication," and "sand bag." Important dimensions and construction details are given with each. A simple equation is given for the oil film pressure in the plain slider bearing. Reviewer believes these models, or equivalent ones, are invaluable not only in academic work but also in design and development work.

V. Johnson, USA

889. Panel on high-speed rolling-contact bearings, Trends of rolling-contact bearings as applied to aircraft gas-turbine engines, SAE Summer Meeting, Atlantic City, N. J., *NACA TN* 3110, 62 pp., Apr. 1954.

Appendixes: (A)—Problems pertaining to high-speed rolling-contact aircraft bearings of concern to the bearing industry, by Gurney, D.; (B)—Problems pertaining to high-speed rolling-contact bearings in aircraft turbine engines of concern to the military, by Michaels, C. M.; (C)—Rolling-contact bearings as applied to aircraft gas turbines from the engine manufacturer's point of view, by Drabek, S.; (D)—New developments in high-speed rolling-contact bearings, by Wellons, F. W.; (E) —Basic friction and wear studies of rolling-contact bearing cage materials, Johnson, R. L., Swikert, M. A., and Bisson, E. E.; (F)—Present status of research knowledge in the field of high-speed rolling-contact bearings, by Macks, E. F.

890. Pestel, E., Contribution to the determination of hydrodynamic damping and vibrating properties of journal bearings (in German), *Ing.-Arch.* **22,** 3, 147–155, 1954.

Paper is devoted to a problem of high engineering significance, because, as is well known, the damping factors of a journal bearing are of great importance in calculations dealing with the stability of a shaft.

With the assumption of creeping motion (Stokes flow) of the lubricant, the inertia terms and the less important part of the terms due to viscosity of the liquid film are neglected. The analysis of a parallel (and with respect to the supporting plane slightly inclined) plane is following by the calculation for a journal bearing. The energy dissipated under a sinusoidal vibration of

small amplitude of the shaft with infinite length and a plate strip, respectively, are pointed out. An approximate solution for the finite journal is given. The damping factors for a finite journal are calculated and plotted for different ratios of diameter of the shaft to the length of the bearing as functions of the Sommerfeld number.

Reviewer believes that in the formulas giving the velocity profile in the lubricant layer (page 149, line 12) there should stand $u = (6xz/h^2)((z/h) - 1)$, as the expression given does not satisfy the correctly written boundary conditions. But as this purely algebraic error is of no importance for the results [achieved] later on, the paper is as useful for the treatment of the situation under critical speeds as for self-excited vibrations of the rotating shaft.

A. Slibar, USA

891. Pinkus, O., Power loss in elliptical and 3-lobe bearings, First Ann. Conf. ASME-ASLE, Baltimore, Md., Oct. 1954. Pap. 54—LUB-9, 11 pp.

Paper concerns the friction of oil film bearings of noncircular cross section subjected to small loads. Operating friction is obtained analytically and compared with experimental results for several bearing contours. Relative friction of lobed bearings to circular bearings of the same surface curvature is obtained as a function of "ellipticity ratio," which is a measure of the deviation of the bearing from circular. Analytical results check well with experimental points.

Reviewer believes the use of the fundamental assumption of constant velocity gradient across the oil film is incorrect for the case of lobed bearings, since this gradient is affected by the film pressures developed in these bearings even with no external applied load. Comparison between circular and lobed bearings would be more useful if bearings with the same amount of shaft "play" or radial freedom had been considered.

J. B. Bidwell, USA

892. Cunningham, R. G., and Schweitzer, P. H., The closed-circuit lubrication system applied to a turbojet aircraft engine, ASME Semi-Ann. Meet., Pittsburgh, Pa., June 1954. Pap. 54—SA-1, 25 pp.

893. Dörr, J., Lubricant film pressure and elastic surface deformation in roller bearings (in German), *Ing.-Arch.* **22,** 3, 171–193, 1954.

Paper provides a quantitative description of the mutual interaction of the pressure in a film of fluid with the shape of the moving bounding walls. Since the pressure in the film is itself dependent on the shape of the bounding walls, this well-known problem leads to quite intractable integral equations. Author solves the equations for the two-dimensional case, assuming fully flooded lubrication and constant oil viscosity, through an iteration method. The numerical solution is carried through for a wide range of the basic variables. Inspection of the graphical presentation of the results suggested rather simple approximate relations between the variables. These are given at the end of the paper and should contribute greatly to its usefulness in the analysis of roller-bearing and spur-gear lubrication problems.

A. Bondi, USA

894. Boeker, G. F., and Sternlicht, B., Investigation of translatory fluid whirl in vertical machines, First Ann. Conf. ASME-ASLE, Baltimore, Md., Oct. 1954. Pap. 54—LUB-3, 17 pp.

Authors suggest the following definitions: "Whip" is an instability caused by factors other than bearing reactions, such as rotor unbalance and the like. "Whirl" is a motion of shaft initiated by hydrodynamic forces within the bearings. In this paper, authors investigate only the "translatory fluid whirl" —i.e., an oscillation of shaft with its axis remaining essentially parallel to axis of bearings—for rigidly mounted bearings operating on a rigid vertical shaft.

A theoretical analysis predicting frequency at which whirl will commence for bearings of finite length is developed by modifying theory proposed by H. Poritsky [AMR **6,** Rev. 3281]. Authors derive a stability criterion for certain types of "anti-whirl" bearings which have some sort of grooving either on journal or bearings or which are shoe-type bearings. The criterion has the same end form as that of Poritsky; however, in contrast to his theory, its constants can be evaluated.

An apparatus was designed and built to measure the threshold whirl frequency of a rigidly supported bearing operating on a stiff vertical shaft. Two types of bearings were tested, an ungrooved journal bearing and a modified combination-type bearing. In order to check the theoretically predicted threshold whirl frequency with the experimental one, determination of eccentricity locus was also made experimentally. Comparison between theoretically predicted threshold whirl frequency and experimentally determined one gives good agreement. The plain journal bearing whirls at all operating speeds. The modified shaft operated smoothly up to the initial threshold whirl frequency of 2700 cpm. Calculated threshold frequency was 2260 (Dennison), 2890 (Needs), or 2910 cpm using Southwell's relaxation method.

W. Kochanowsky, Germany

895. Feng, I.-M., and Uhlig, H. H., Fretting corrosion of mild steel in air and in nitrogen, *J. appl. Mech.* **21,** 4, 395–400, Dec. 1954.

Authors use weight loss as measure of damage to cylindrical specimens subject to oscillatory slip of 0.0004 to 0.0091 in. at 56 to 3000 cpm. Fretting damage increases with decreasing humidity, decreasing ambient temperature, increasing relative slip, increasing load, and decreasing frequency. Weight loss is less in moist or dry nitrogen than in air.

W. J. Anderson, USA

896. Uhlig, H. H., Mechanism of fretting corrosion, *J. appl. Mech.* **21,** 4, 401–407, Dec. 1954.

Fretting is shown to be partly chemical and partly mechanical. A quantitative expression for weight loss relating variables involved is derived. Calculated and observed weight losses correlate fairly well.

Reviewer believes that data from other apparatus must be used to check general applicability of the equation. In particular, a sinusoidal velocity distribution, which may not be true for other apparatus, was assumed in the derivation.

W. J. Anderson, USA

897. Rightmire, B. G., and Bonneville, J. M., Fundamental study of erosion caused by steep pressure waves, *NACA TN* 3214, 30 pp., June 1954.

A fundamental study of erosion caused by steep pressure waves has been carried out. It is believed that the study gives an insight to the possible causes of damage in high-speed sleeve bearings. In particular, the effect on annealed copper surfaces of steep-fronted pressure waves in oil has been studied, the general conclusion being that cavitation of the oil is the probable cause of damage.

From authors' summary by J. J. Ryan, USA

Marine Engineering Problems

(See also Revs. 590, 594)

898. Weinblum, G., Systematic development of ship hull forms (in German), *Jahrb. Schiffbautech. Gesellsch.* **47**, 186–215, 1953.

This paper is the first part of a more extensive treatise, the object of which is to establish a mathematical system in the vast area of ship form geometry with the ultimate purpose of defining analytically the optimum hull form complying with specific basic requirements with regard to stability, resistance, seakeeping qualities, maneuverability, strength, and freedom of vibrations. The conception of the dimensionless hull form and its mathematical formulation is discussed at length. These tools prove useful to the investigation of important properties of the various hull forms. Some observations from mechanics in the fields of stability and wave-making resistant theory are given. The importance of the curve of sections for minimum resistance and its mathematical approximation by high-order polynomials is emphasized. Some striking examples are given with respect to reduction of wave-making resistance by evaluation of Michell's integral and the application of the Ritz method.

L. Troost, USA

INDEX OF AUTHORS REFERRED TO IN THIS ISSUE

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